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CIVIL ENGINEERING.

On the Wear and Tear of Steam Boilers. By FREDERICK ARTHUR PAGET, Esq., C.E.

(Continued from page 157.)

From the Journal of the Society of Arts, No. 649.

DISCUSSION.—Mr. LEWIS OLRICK said there were some points in the paper with which he did not agree. It was stated by Mr. Paget that one cause of injury to steam boilers was the percussive action of the steam when suddenly cut off by the slide valve, which caused a recoil upon the sides of the boiler. On this point he would remark that, in the great majority of boilers used in England, the slide valve did not suddenly cut off the steam; in most cases the slide valve was moved by an eccentric, and the cutting off was gradual, and not sudden as in the case of the American engines; and this remark, therefore, only applied to those engines where the expansion gear acted suddenly. Allusion had been made to the straining of the cylinder covers. He had seen such cases, and he had also observed the foundation plate give at each stroke of the engine; but he had no doubt if Mr. Paget had examined the plates in such cases, he would have found that this was not caused by the percussive action of the steam, but was owing to an insufficient amount of metal, and insufficient strength put into the proper place. He had noticed this in the case of an engine of twenty horse power, which had been in use for many years in the factory of Messrs. Maudslay, where there was an insufficiency of metal in the proper place. He had never seen it where the cylinder covers were strong enough for the work they were expected to do. Another point mentioned by Mr.

Paget was, that the steam room in the boiler should be proportionate to the size of the cylinder; he should have been glad if Mr. Paget had stated what he considered to be the proper proportions. Reference had been made to the caulking of boilers under pressure. This might be done when a boiler was tried by the hydraulic test, but the proper way was to take off the pressure, and then caulk and put on the pressure again. It was only the question of a minute to pump the pressure up again, and a few strokes more gave the additional pressure, beyond the former one indicated by the chalk mark. The next point he would allude to was with regard to the feed-water. It would appear that many engineers did not consider it wrong to insert the feed-water pipe near the fire-box. Quite recently he had seen that done in the case of a locomotive in which a Giffard's injector was employed; and he would call the attention of those who had not considered the subject to the explanations which Mr. Paget had given as to the injurious action of the feed-water on the boiler plates. The next point in the paper had reference to the superior heat conducting power of thin boiler plates as compared with thick. This was no doubt the case, but in speaking of the American plates, Mr. Paget had omitted to mention the superior quality of those plates, which made it possible to use them of a thickness which would not be ventured upon in England. Within the last few years the quality of the best plates in this country had almost come up to the American standard, but those generally used were not so good. Allusion had been made to the voltaic action that took place in steam boilers, and the evils that might follow from it. Some years ago a pamphlet was published by Mr. Zerah Colburn, in which the action of steam boiler explosions was explained, and the question of the galvanic action was based upon the high authority of Professor Faraday, to which he (Mr. Olrick) would willingly bow. He entirely agreed with the general remarks in the paper with respect to explosions. They involved the sacrifice of a great amount of life and property, and he thought it would be desirable for the government to take this matter in hand, and to introduce stringent rules to make people more careful with their boilers. The greatest amount of mischief was occasioned by employing men to attend boilers who knew nothing whatever of the properties of the steam engine. It was a question which could not be too much impressed upon people, that there should be proper periodical inspections of boilers, according to the system adopted by the Manchester Association. Mr. Paget had mentioned the hydraulic test. There was a great difference of opinion amongst engineers on that question, but no doubt, as Mr. Paget had pointed out, practical experience led to the conclusion that in all cases where this test was carefully applied, there was much fewer explosions than where it was neglected. The cases of locomotive engine explosions had occurred solely on lines where that test was not employed. On the subject of the wear and tear of steam boilers, he would remark that the great cause was defined by the single word "neglect," often on the part of the designer and manufacturer. When a boiler was made too small, there must be forced firing, and the consequence of that was early destruc-

tion of the boiler. A further deteriorating cause was defective circulation producing similar consequences. There was one point which it was almost unnecessary to mention, viz: that if boilers were not properly stayed, they would give way earlier than if proper attention was paid to the staying. But the great evil arose after the boilers came into the hands of the owners, from employing unskilled persons to work them. The amount saved in wages in this respect was an injudicious economy, and it was a question whether parties who confided boilers to such people ought not to be made responsible in a court of justice in the event of explosions taking place. Amongst the various evils to which steam boilers were exposed there was none worse than bad feed-water, which was a frequent cause of their destruction. A most grievous evil was scale in the boiler, which lowered the heating power, and thus it was most important that it should be frequently removed. Scaling arose from bad water, but as rain water was not generally to be procured, they had to be satisfied with well water, which was generally very hard, and which led to large deposits of sulphate of lime in the boiler. For the removal of the carbonate of lime from the feed-water, he believed Dr. Clark's process was very effective, though the means by which the result was accomplished would appear strange to those unacquainted with the subject. Lime was added in excess, which caused the precipitation of the salts of lime already in solution, and thus the water was purified.* There was also another plan, which had been successful in preventing scale, known as Martin's invention, which he had no doubt was also efficient. In that plan the feed-water was made to pass through a cylinder containing plates arranged diagonally and filled with superheated steam; the water deposited its scale upon these plates before entering the boiler. The consequence of this was a clean boiler instead of the accumulation of scale. The usual way of removing scale was sending boys with hammers into the boilers and knocking it off, which often caused great injury to the structure of the boiler, from carelessness in the operation. He was sure they must all feel indebted to Mr. Paget for his valuable and exhaustive paper.

Mr. STENSON remarked that mention was made in the paper of the circumstance of the stay bars in boilers being in a crystalline state, and only requiring a slight blow of a hammer to break them. He had heard papers read before this and other societies in which this question had been debated, but there was one point which required first to be settled, viz: the real condition of the iron previous to its being made into stays. Was it crystalline before it was so used? or had it become so by use? He had been connected with engineering the greater part of his life, and he must say he had never met with an instance in which it was satisfactorily proved that the iron had been converted from its fibrous condition before use. It was asserted that percussive action tended to produce a crystalline condition of the iron. This might be so, but he required further proof of it. He had cut up and examined a great many piston rods and connecting rods of locomotive

* *Journal of the Society of Arts*, vol. iv., page 424.

engines working at great velocity; he had found them to be in various states—some partly crystalline and some entirely so, while others had remained fibrous throughout; and he had found the same characteristics of inequality in the tires of railway wheels. The leakage of boilers had been referred to in the paper, and he held it to be a very important subject for investigation. He knew from experience with boilers in his own use, that a very small leakage would destroy the plate from the outside. The oxydation commenced at the spot, not where the water leaked, but where it evaporated and the plate was dry. The destruction of the plate from this cause was so rapid that he had known a $\frac{3}{8}$-inch plate cut through by a small leakage in a few months after the boiler was put up. He had no doubt this was caused by the chemical action upon the plate. With regard to scale, Mr. Olrick had mentioned a plan which he regarded as efficient in preventing the usual effects of the deposition of carbonate and other salts of lime in steam boilers. There could be no doubt of the destructive effects of those deposits upon the plates of the boiler, as also of the retardation thus caused to the heat. He should be glad to hear some further explanation of Mr. Martin's process, as he regarded scale as the greatest element of destruction with which they had to contend in the working of steam boilers.

Mr. ADAMS, whilst agreeing to a great extent with what had been stated in the paper, took exception to the remark that the method of welding plates reduced their strength. He had seen many successful experiments in welding, by Bertram's process, at Woolwich, and it was invariably found, under ordinary circumstances, that the weld was the strongest part of the plate, for it was a well known fact that a piece of iron forged after it came from the rollers was stronger than when it left the rollers. Mr. Paget had quoted from some German authorities respecting the temperature at which water was decomposed, but he would state a practical fact within his own experience. On one occasion the steam was allowed to stand stagnant for ten days, and on the tenth day the metal of the superheater ran away into the fire, but no decomposition of the water had taken place. With regard to the hydraulic testing of boilers, engineers were not agreed as to whether the testing should be made at a high temperature or not. They knew, in testing a boiler cold, they had the friction of the rivets; but in hot testing the expansion of the metal by heat caused a great difference. The rivets expanded to a greater extent than the plate itself, because the expansion of the rivets was longitudinal and along the fibre, whereas the expansion of the plate was across the fibre and not so great, and the power which the friction of the rivets gave to the strength of the plate would be less when cold; but to oppose that there was the greater strength of the plate due to the low temperature. Mr. Adams then, by means of a diagram, described in detail Martin's process for preventing incrustation in boilers.

Mr. G. F. WILSON, F.R.S., on the subject mentioned in the paper as to water or steam in contact with iron being decomposed, would give an instance in his own experience where such was not the case at a very high temperature. It had come under his observation that steam

passing day by day through iron pipes at a red heat was not decomposed, or there was no evidence of its decomposition. The theory was that hydrogen ought to have been formed, and an explosive mixture should have been generated, but practically such explosive compound was not formed.

Mr. OLRICK wished to add, with reference to the hydraulic testing of boilers, that he had in many instances used hot water for the test up to 200 degrees, as by that means the boiler was brought into a very similar state to what it would be in when at full work.

The CHAIRMAN said it now became his duty to move that the thanks of the meeting be given to Mr. Paget for the paper with which he had favored them. It was very comprehensive in its scope, and he thought contained many valuable suggestions. No doubt public safety was of the first importance in matters of this kind, and the mode in which that could be best obtained seemed to be practically indicated by the inspections undertaken by the Manchester Society. Other means, no doubt, might be taken for ensuring the safety of the public; but there was no plan so effective as when the public took care of itself, as was the case at Manchester. With regard to the economy of wear and tear, it was a question for engineers, and one upon which he could not venture to give an opinion; but, undoubtedly, it was an important question for those who employed steam boilers in their manufactories in which a large amount of capital was invested. They must all feel indebted to Mr. Paget for his careful investigation of the subject, and the able manner in which he had treated it in his paper.

The vote of thanks having been passed,

Mr. PAGET, in acknowledging the compliment, said that a perusal of his paper would show that he had very carefully guarded himself from stating that any impulsive action on the sides of the boiler could be brought to bear by means of the gradual action of the side-valve. In speaking of the effect of galvanism on steam boilers, he, of course, only meant the chemical action on the plates producing wear and tear, and therefore to the primary ruptures leading to explosions. With respect to incrustations, he thought that the effects they produced were simply those which ensued when a plate got red hot. In speaking of the charcoal plates used in America, he was necessarily aware of their superiority to iron made with pit-coal. Testing boilers by means of hot w ter instead of cold, was often, as he said, very advantageous, and, indeed, necessary. With regard to the crystallization of iron, and with respect to Mr. Stenson's remarks, he thought that this state was simply due to strains in excess of the elastic limit, abstracting elasticity and ductility, and therefore inducing brittleness. The crystallized appearance of a surface of fracture was simply due to the mode of fracture. His observations with regard to Bertram's joints were founded on the results of experiments conducted at Woolwich for the Admiralty. With respect to boiler insurance companies, their action undoubtedly offered the best means of safety and economy; at the same time, their future spread needed some extraneous stimulus, more especially in sparsely populated districts, like the agricultural and some of the mining counties.

Professor Zeuner's Table of the Properties of Saturated Steam.

From the London Artizan, June and December, 1864.

The table we publish in our present number is a reproduction of that computed by Herr G. Zeuner, Professor of Applied Mechanics at the Federal Polytechnic Institute, of Zurich. We have added columns 3, 5, 7, 15, and 17, in order to render the results more intelligible to our readers. The table is based on the mechanical theory of heat. Prof. Zeuner states that he calculated the values given in the table by means of Thomas' calculating machine which proved very useful for this purpose.

The first column contains the pressure of steam in atmospheres, advancing by tenths of an atmosphere from one to seven, and by fourths from 7 to 14 atmospheres. In the second and third columns the same pressures are given in millimetres and inches of mercury, as denoted by the barometer; while in the fourth and fifth columns, the same pressures are given respectively in kilograms and pounds per square meter and square inch. The sixth and seventh columns contain the centigradial and Fahrenheit degrees of heat for the various pressures of saturated steam, as deduced by interpolation from Regnault's data. Thus, the temperature of saturated steam at a pressure of five atmospheres is 151·22° C = 306·00 F.

To render columns 8, 9, and 10 intelligible, the following deductions will be required: Supposing a certain space, for example, a cylinder of a section F to contain 1 kilogram of water at 0° (C), and, by heating it, saturated steam of a pressure of p (kilos per square metre) and a given temperature to be intended to be produced. The cylinder piston rests on the surface of the water, and at a distance s_1 from the bottom; the volume of water contained in the cylinder will be, therefore,

$$F s_1 = w.$$

The piston is also supposed, at the beginning of the trial, to be loaded by a weight p per unit of area, and the pressure on the piston to be equal to that of the steam to be generated. In heating the water, its temperature will at first rise from 0° to t° (C), before steam is generated; then, at a temperature t, the expansive force of the steam will be sufficient to overcome the pressure p, and thus to move the piston.*

Let q be the quantity of heat necessary to raise the temperature of the water from 0° to t°. This quantity, according to Regnault's formula, will be

$$q = t + \cdot00002\,t^2 + \cdot0000003\,t^3, \quad . \quad . \quad (1.)$$

If the heating process continues, steam will be generated that will reach the pressure p, and the piston will be pushed forward, until the whole of the water has been transformed into steam; supposing, at this moment, the distance of the piston from the bottom of the cylinder to

* In all these calculations the kilogram, the metre, and the degrees of the centigradial thermometer are adopted as units. The columns 3, 5, 7, 15, and 17 were inserted in our table merely for the convenience of those not acquainted with the decimal (metrical) weights, measures, &c.

be $= s_2$, the volume of the unit of weight of steam generated at a pressure p will be

$$\text{F}\, s_2 = v.$$

During the evaporation, the pressure and temperature remain constant, the heat r that must be supplied during the operation is called *latent heat*, or, according to Clasius, *heat of evaporation*. The total quantity of heat that must be supplied to water at 0°, in order to obtain, under a constant pressure, the unit of weight of steam of a pressure p, is

$$\text{Q} = q + r \quad . \quad . \quad . \quad . \quad (2),$$

for which value of Q (generally called the *aggregate heat of steam*) M. Regnault gives the formula

$$\text{Q} = 606{\cdot}5 + {\cdot}305\, t, \quad . \quad . \quad . \quad (2a.)$$

Now, the steam has, during its generation, performed a certain amount of work, having acted with a pressure F p on the piston, which has traveled through a space $s_2 - s_1$; the work done will be, therefore,

$$\text{F}\, p\, (s_2 - s_1);$$

or else, as we called

$$\text{F}\, s_2 = v \text{ and } \text{F}\, s_1 = w,$$

it will be

$$p\,(v - w).$$

The value $v - w$ represents the difference between the unit of weight (1 kilo) of steam at a pressure p, and the corresponding unit of weight of water, which latter may be considered constant at the various temperatures and = 1 cubic decimetre. To simplify the calculation, we shall call

$$v - w = u \quad . \quad . \quad . \quad (3),$$

so that the labor performed by the unit of steam during its formation will be $= p\, u$.

Now, according to the mechanical theory of heat, every production of work requires the transformation of a certain quantity of heat, and it has been ascertained by experiments that one unit of heat or a *calorie* can be produced by a quantity of work = to 424 kilogrammetres; or reciprocately $\frac{1}{424} = \text{A}$ will be the quantity of heat corresponding to one unit of work, or one kilogrammetre. A is the calorific equivalent of one unit of work. In multiplying by A the quantity of work $p\, u$ required for generating steam under a constant pressure p, the coefficient

$$\text{A}\, p\, u$$

will represent the quantity of heat that is absorbed during this formation. From the quantity of heat Q required to transform at a constant pressure p one unit of weight of water of 0° into steam of a pressure p, will therefore be abstracted the quantity of heat A $p\, u$ during the process of generation of steam, *i.e.*, another quantity of heat J will be obtained through the equation

$$\text{J} = \text{Q} - p\, u, \quad . \quad . \quad . \quad . \quad (4.)$$

This is called *the heat contained in the steam*, or *the heat of steam*. J also indicates how many calories (units of heat) will be found in one unit of weight of saturated steam of a pressure p, in addition to those contained in one unit of weight of water at a temperature 0°.

The latent heat or *heat of evaporation* r, on the contrary, represents, according to our notations, the quantity of heat that must be supplied to the water that has already been brought to the temperature of the steam to be generated, in order to convert it into steam, supposing, however, the generation of steam to take place under a constant pressure. In deducting, therefore, the quantity $A\,p\,u$ of heat converted into work from the value r, the difference ρ will denote by what amount of heat the unit of weight of steam of a temperature t will exceed the unit of weight of water of the same temperature.

The coefficient

$$\rho = r - A\,p\,u \quad . \quad . \quad . \quad . \quad (5)$$

is called the *internal latent heat*.

The two quantities J and ρ are very important coefficients. They are both entirely independent of the way in which the steam is generated; whereas, in introducing in calculations the total heat Q, and the heat of evaporation r, it must be borne in mind that with them the generation of the steam is supposed to take place under a constant pressure.

The quantity of heat converted into labor during the process of generation of steam under a constant pressure may be noted with very great precision by the empirical formula

$$A\,p\,u = B \log \frac{T}{n}, \quad . \quad . \quad . \quad . \quad (6,)$$

in which B and n are two constants, for which in calculation 30,456 for B, and 100 for r have to be substituted. T is what is called the *absolute temperature*, *i.e.*,

$$T = 273 + t.$$

The column (8) has been calculated by means of formula (6).

The values of Q and r, in formulæ (4) and (5) being known from Regnault's experiments, the coefficients J and ρ may be deduced therefrom. In availing himself of these experiments, Prof. Zeuner found for the heat of evaporation, the formula

$$J = 573{\cdot}34 + {\cdot}2342\,t, \quad . \quad . \quad . \quad (7,)$$

for which he calculated the values contained in column (9).

He found, moreover, for the temperatures that are met with in steam engines, that the internal latent heat is represented by the formula

$$\rho = 575{\cdot}03 - {\cdot}7882\,t, \quad . \quad . \quad . \quad . \quad (8,)$$

from which the tenth column has been calculated.

EXAMPLE.—Supposing the steam to act at a pressure of 5 atmospheres, the heat converted into labor is

$$A\,p\,u = 44{\cdot}083 \text{ calories},$$

for a quantity of labor corresponding to

$$44{\cdot}083 \times 424 = 18{,}691{\cdot}19 \text{ kilogrammetres},$$

the heat of steam being

$$J = 608{\cdot}99 \text{ calories},$$

and the internal latent heat

$$\rho = 455{\cdot}05.$$

From equation (4) is found, as the total heat of this steam,

$$Q = J + A\,p\,u = 653{\cdot}07,*$$

and the heat of evaporation

$$r = \rho + A\,p\,u = 499{\cdot}13.\dagger$$

The equation

$$J - \rho = q, \quad . \quad . \quad . \quad . \quad . \quad (9,)$$

which is obtained by deducting formula (5) from (6), will be found to agree with equation (2). From equations (7) and (8) is deduced, for the heat that can bring water from $o°$ to $t°$,

$$q = -1{\cdot}69 + 1{\cdot}0224\,t, \quad . \quad . \quad . \quad (10,)$$

which is a convenient coefficient for the temperatures steam engines generally work at.

It may be concluded therefrom that the specific heat of water at average temperatures will be

$$c = 1{\cdot}0224, \quad . \quad . \quad . \quad . \quad (11.)$$

The foregoing explanations are sufficient to render the next columns of the table intelligible. Column 11 contains the values of u, which are obtained by dividing the coefficients $A\,p\,u$ of column 8 by $A\,p$. Column 12 contains the values of the coefficient $\frac{p}{u}$, deducted from columns 10 and 11. These latter coefficients will prove to be of very great importance in practice.

The value of equation (3) differs very little from v, the specific volume of water u being so small, as compared to w, that, in most cases, it may be neglected with safety. ρ denotes the internal latent heat of the unit of weight, and consequently, $\frac{p}{u}$ may be considered as *the internal latent heat of the unit of volume* (*i.e.*, 1 cubic metre) of steam.

The column 13 shows that the differences in the values of $\frac{p}{u}$ decrease very slowly with the pressure; this internal latent heat of the unit of weight is therefore proportioned to the tension of steam.

Finally, we may deduct from formula (3) the specific volumes of the steam, or the volume of 1 kilogramme of steam at different pressures, and

$$v = u + w \quad . \quad . \quad . \quad . \quad . \quad (12)$$

for the specific weight of steam we have seen that we may take $w = \cdot001$; in this manner the value of v may be obtained. These values

* Mr. Regnault's formula (2 bis.) gives 652·93.

† According to Regnault's formula $r = 499{\cdot}20$.

are contained in column 14 in cubic metres for kilogrammes, and in column 15 in cubic feet for pounds avoirdupois. The density γ, or weight of 1 cubic metre of steam at various temperatures, may be reciprocally obtained by the formula

$$\gamma = \frac{1}{v}, \quad . \quad . \quad . \quad . \quad . \quad (13.)$$

These values are contained in a like manner in columns 16 and 17, respectively for French and English measures and weight.*

We have given Herr Zeuner's table, with the deductions from which the results contained therein were arrived at. We now give, by way of example, the problem worked out by Professor Zeuner himself, in order to illustrate the application of the table.

The question to be solved is the following: *In what manner will the pressure of steam increase in a boiler which is continued to be heated after the egress of steam has been stopped, and the valve shut off from a certain moment.*

Supposing the weight of water and steam combined in the boiler to be M kilos., m kilos. of which being steam, at the moment the valve is shut off, t = the temperature, p the pressure, and all other letters to denote the same as before, (see page 222,) the volume of water contained within the boiler will then be $= (M - m)\,w$, the volume of steam $= m\,v$; therefore the volume of the water and steam combined

$$V = (M - m)\,w + m\,v = M\,w + m\,(v - w);$$

or, by equation (3),

$$V = M\,w + m\,u.$$

Supposing the quantity of steam in the boiler to increase by the heating process, and m to assume the value m_1, t the value of t_1, and p the value of p_1, after the lapse of τ minutes; the value of u will become u_1, as there is no change in the volume, and we shall have

$$V = M\,w + m_1\,u_1$$
$$m_1\,u_1 = m\,u.$$

The quantity of steam, m, can therefore easily be calculated for every temperature t_1.

The quantity of heat that was contained in the water at the beginning was $= (M - m)\,q$, that contained in the steam was $= m\,J$; therefore the quantity of heat contained in the volume of water and steam combined will be

$$(M - m)\,q + m\,J = M\,q + m\,(J - q)$$
$$J - q = \rho \text{ (by equation (9))}$$
$$\therefore M q + m\,(J - q) = M\,q + m\rho.$$

For a temperature, t_1, we shall have

$$M\,q_1 + m_1\rho_1,$$

and consequently, the quantity of heat to be supplied, in order to raise

* 1 kilogramme = 2·205 lbs. avoirdupois; 1 metre = 100 centimetres = 3·2809 ft.; 1 square metre = 10,000 square centimetres = 10·76 square ft.; 1 cubic metre = 35·32 cubic feet.

TABLE *of the Properties of Saturated Steam.*

Pressure in				Temperature.		Quantity of steam converted into work during the production of steam.	Heat of steam.	Latent internal heat.	Values of n.	Values of $\frac{\rho}{n}$.	Differences.	Volume.		Density.	
Atmospheres.	Millimetres of Mercury.	Inches of Mercury.	Kilogrammes per square metre.	Lbs. avoirdupois per square inch.	Centigradial.	Fahrenheit.	$n\rho u$	s	ρ	n			Volume of one kilogramme of steam in cubic metres.	Corresponding volume of 1 lb. avoirdupois in cubic feet.	Weight of 1 cubic metre in kilogrammes.	Corresponding weight of 1 cubic foot in lbs.
			ρ		t								a		γ	
0·1	76	3	1033·4	1·470	46·21	115·18	35·349	584·16	538·61	14·5034	37·14	32·95	14·5044	184·563	0·069	·0054
0·2	152	6	2066·8	2·939	60·45	140·81	36·679	587·51	527·38	7·5246	70·09	31·37	7·5256	95·760	0 133	·0105
0·3	228	9	3100·2	4·409	69·49	157·02	37·493	589 61	520·26	5·1278	101·46	30·34	5·1288	65·262	0·195	·0153
0·4	304	12	4133·6	5·879	76·25	169·25	38·089	591·20	514·93	3·9069	131·80	29·57	3·9079	49·726	0·256	·0201
0·5	380	15	5167·0	7·349	81·71	179·26	38·562	592·48	510·63	3·1644	161·37	28·96	3 1654	40·262	0·316	·0248
0·6	456	18	6200·4	8·818	86·32	187·38	38·954	593·56	506·99	2·6638	190·33	28·44	2·6648	33·909	0·375	·0295
0·7	532	21	7233·8	10·288	90·32	196·36	39·292	594·49	503 84	2·3830	218·77	28·00	2 3040	29·318	0·434	·0341
0·8	608	24	8267·2	11·758	93·88	200·98	39·589	595·33	501·03	2 0804	246·77	27·61	2·0814	25·849	0·492	·0387
0·9	684	27	9300·6	13·227	97·08	206 74	39·853	596·08	498·51	1·8168	274·38	27·27	1·8178	23·131	0·550	·0432
1·0	760	30	10334·0	14·697	100·0	212 00	40 092	596·76	496·21	1·6450	301 05	26·97	1·6460	20·950	0·617	·0477
1·1	836	33	11367·4	16·167	102·68	216·82	40·310	597·39	494·10	1·5036	328·62	26·67	1·5046	19·145	0·665	·0523
1·2	912	36	12400·8	17·636	105·17	221·31	40·512	597·97	492·13	1·3851	355·29	26·41	1·3861	17 638	0·722	·0567
1·3	988	39	13434·2	19·106	107·50	225·35	40·699	598·52	490·30	1·2845	381·70	26·18	1·2855	16·358	0·778	·0611
1·4	1064	42	14467·6	20·576	109·68	229·42	40·873	599·03	488·58	1·1978	407·88	25·94	1·1988	15·254	0·834	·0655
1·5	1140	45	15501·0	22·046	111·74	233·13	41·036	599·51	486·96	1·1225	433·82	25·74	1·1235	14·296	0·890	·0699
1·6	1216	48	16534·4	23·515	113 69	236·72	41·190	599 97	485·24	1·0563	459·56	25·55	1·0573	13·454	0·946	·0743
1·7	1292	51	17567·8	24·985	115·54	239 97	41·336	600·40	483·96	0·9976	485·11	25·36	0·9986	12·707	1·001	·0787
1·8	1368	54	18601·2	26·455	117·30	243·14	41·473	600 81	482·57	0 9453	510·47	25·17	0·9463	12·041	1·057	·0831
1·9	1444	57	19633·6	27·924	118·99	246·18	41·605	601·21	481·24	0·8984	535·64	25·03	0·8994	11·444	1·112	·0874
2·0	1520	60	20668·0	29·394	120·60	249·08	41·730	601·58	479·97	0 8561	560·67	25·03	0·8571	10·906	1·167	·0917
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**

(TABLE CONTINUED.)

Pressure in				Temperature.		Quantity of steam converted into work during the production of steam.	Heat of steam.	Latent internal heat.	Values of n.	Values of $\frac{p}{n}$.	Differences.	Volume.		Density.
Atmospheres.	Millimetres of Mercury.	Inches of Mercury.	Kilogrammes per square metre.	Lbs. avoirdupois per square inch.	Centigradial.	Fahrenheit.	$x\ p\ u$	r	ρ				Volume of one kilogramme of steam in cubic metres.	Corresponding volume of 1 lb. avoirdupois in cubic feet.	Weight of 1 cubic metre in kilogrammes.	Corresponding weight of 1 cubic foot in lbs.
												a		Δ	
2·1	1596	63	21701·4	30·864	122·15	251·87	41·849	601·95	478·75	0·8176	585·52	24·85	0·8186	10·416	1·222	·0960
2·2	1672	66	22734·8	32·333	123·64	254·55	41·964	602·30	477·58	0·7826	610·23	24·71	0·7836	9·971	1·276	·1003
2·3	1748	69	23768·2	33·803	125·07	257·13	42·073	602·63	476·45	0·7505	634·80	24·57	0·7515	9·563	1·331	·1046
2·4	1824	72	24801·6	35·273	126·46	259·63	42·180	602·96	475·35	0·7211	659·21	24·29	0·7221	9·188	1·385	·1088
2·5	1900	75	25835·0	36·743	127·80	262·04	42·282	603·27	474·30	0·6939	683·50	24·16	0·6949	8·842	1·439	·1131
2·6	1976	78	26868·4	38·212	129·10	264·38	42·380	603·57	473·27	0·6688	707·66	24·05	0·6698	8·523	1·493	·1173
2·7	2052	81	27901·8	39·682	130·35	266·63	42·475	603·87	472·29	0·6454	731·71	23·92	0·6464	8·225	1·547	·1216
2·8	2128	84	28935·2	41·151	131·57	268·83	42·567	604·15	471·33	0·6237	755·63	23·79	0·6247	7·949	1·601	·1258
2·9	2204	87	29968·6	42·620	132·76	270·97	42·656	604·43	470·39	0·6035	779·42	23·70	0·6045	7·692	1·654	·1300
3·0	2280	90	31002·0	44·091	133·91	273·04	42·742	604·70	469·48	0·5846	803·12	23·60	0·5856	7·452	1·708	·1342
3·1	2356	93	32035·4	45·561	135·03	275·05	42·826	604·96	468·60	0·5668	826·72	23·48	0·5678	7·225	1·761	·1384
3·2	2432	96	33068·8	47·130	136·12	277·02	42·907	605·22	467·74	0·5501	850·20	23·37	0·5511	7·012	1·814	·1426
3·3	2508	99	34102·2	48·600	137·19	278·94	42·987	605·47	466·90	0·5345	873·57	23·29	0·5355	6·814	1·867	·1467
3·4	2584	102	35135·6	49·970	138·23	280·81	43·064	605·71	466·08	0·5197	896·86	23·19	0·5207	6·626	1·920	·1509
3·5	2660	105	36169·0	51·439	139·24	282·63	43·139	605·95	465·27	0·5057	920·05	23·11	0·5067	6·448	1·973	·1551
3·6	2736	108	37202·4	52·909	140·23	284·41	43·212	606·18	464·50	0·4925	943·16	22·98	0·4935	6·280	2·026	·1592
3·7	2812	111	38235·8	54·379	141·21	286·18	43·284	606·41	463·73	0·4800	966·14	22·95	0·4810	6·121	2·079	·1634
3·8	2888	114	39269·2	55·849	142·15	287·87	43·353	606·63	462·99	0·4681	989·09	22·83	0·4691	5·969	2·132	·1675
3·9	2964	117	40302·6	57·318	143·08	289·54	43·421	606·85	462·25	0·4568	1011·92	22·71	0·4578	5·833	2·184	·1716
4·0	3040	120	41336·0	58·788	144·00	291·20	43·488	607·06	461·53	0·4461	1034·63	22·71	0·4471	5·689	2·237	·1758
4·1	3116	123	42369·4	60·258	144·89	292·80	43·553	607·27	460·83	0·4358	1057·31	22·68	0·4368	5·558	2·289	·1799

4·0	3040	120	41336·0	58·788	144·00	291·20	43·488	607·06	461·53	0·4401	1054·53	22·68	0·4471	5·669	2·287	·1780
4·1	3116	123	42369·4	60·258	144·89	292·80	43·553	607·27	460·83	0·4358	1057·31		0·4368	5·558	2·289	·1799
4·2	3192	126	43402·8	61·727	145 76	294 37	43·617	607·48	460·14	0·4261	1079·91	22·60	0·4271	5·435	2·341	·1840
4·3	3268	129	44436 2	63·197	146·61	295·90	43·678	607·68	459·47	0·4168	1102·45	22·54	0·4178	5·316	2·393	·1881
4·4	3344	132	45469·6	64·667	147·46	297·43	43·740	607·87	458·80	0·4079	1124 87	22·42	0·4089	5·203	2·446	·1922
4·5	3420	135	46503·0	66·137	148·29	298 92	43·800	608·07	458·15	0·3993	1147·21	22·34	0·4003	5·094	2·498	·1963
4·6	3496	138	47536·4	67·606	149·10	300·38	43·859	608 26	457·51	0·39.2	1169·51	22·30	0·3922	4·991	2·550	·2004
4·7	3572	141	48569·8	69 076	149·90	301·82	43 916	608 45	456·88	0·3834	1191·71	22 20	0·3844	4·891	2·602	·2045
4·8	3648	144	49603·2	70·546	150·69	303 32	43·973	608·63	456·26	0·3759	1213·85	22·14	0·3769	4·796	2·653	·2085
4·9	3724	147	50636·6	72·015	151·46	304·63	44·028	608 81	455·65	0·3687	1235·93	22·01	0·3697	4·704	2·705	·2126
5 0	3800	150	51670·0	73·485	152.22	306·00	44 083	608 99	455·05	0·3617	1257·94	21·93	0·3627	4·615	2·757	·2167
5·1	3876	153	52703·4	74 955	152·97	307·35	44·137	609·16	454·46	0·3551	1279·87	21·91	0 3561	4·531	2·807	·2206
5·2	3952	156	53736·8	76·424	153·70	308·66	44·189	609·34	453·88	0·3487	1301·78	21·79	0·3497	4·450	2·859	·2247
5·3	4028	159	54770·2	77·894	154 43	309·97	44·241	609·51	453·31	0·3425	1323·57	21·77	0·3435	4·371	2·911	·2288
5·4	4104	162	55803·6	79·364	155 14	311·25	44·291	609 67	452·75	0·3365	1345·34	21 66	0·9375	4·295	2·963	·2329
5 5	4180	165	56837·0	80·833	155·85	312 53	44·342	609·84	452·19	0 3308	1367·0	21·66	0·3318	4·222	3·014	·2369
5·6	4256	168	57870·4	82·301	156 54	313·77	44·391	610·00	451·64	0·3252	1388·66	21·58	0·3262	4·151	3·066	·2410
5·7	4332	171	58903·8	83·773	157·22	315·00	44·439	610·16	451·11	0·3199	1410·24	21·49	0·3209	4·083	3·116	·2449
5·8	4408	174	59937·2	85·241	157·90	316·22	44·487	610·32	450·57	0·3147	1431·73	21·47	0·3157	4 017	3·168	·2490
5·9	4484	177	60970·6	86·710	158·56	317·40	44·534	610·47	450 05	9·3097	1453·20	21·39	0·3107	3·954	3·219	·2530
6·0	4560	180	62004·0	88·182	159·22	318·60	44·580	610·63	449·53	0·3048	1474·59	21·34	0·3058	3 891	3·270	·2570
6·1	4636	183	63037·4	89·652	159·87	319·77	44·656	610·78	449·02	0·3002	1495 93	21·33	0·3012	3·833	3·320	·2609
6·2	4712	186	64070·8	91·121	160·50	320·90	44·670	610·93	448·52	0·2956	1517·26	21·18	0·2966	3·774	3·371	·2649
6·3	4788	189	65104·2	92·591	161·14	322·05	44·715	611·08	448·02	0·2912	1538·44	21·21	0·2922	3·718	3·422	·2689
6·4	4864	192	66137·6	94·261	161·76	323·17	44·759	611·22	447·53	0·2869	1559·65	21·16	0·2879	3·663	3·472	·2729
6·5	4940	195	67171·0	95 731	162·37	324·27	44·801	611·37	447·05	0·2828	1580·81	21·06	0·2838	3 611	3·523	·2769
6·6	5016	198	68204·4	97·200	162·98	325·36	44·844	611·51	446·57	0·2788	1601·87	21·03	0·2798	3·560	3·574	·2809
6·7	5092	201	69237·8	98·470	163·58	326·54	44·886	611·65	446·10	0·2749	1622·90	20·97	0·2759	3·511	3·624	·2848
6·8	5168	204	70271·2	99·940	164·18	327·70	44·928	611·79	445·62	0·2711	1643·87	20·95	0·2721	3·462	3·674	·2887
6·9	5244	207	71304·6	101·409	164·76	328·57	44·968	611·93	445·17	0·2674	1664·82	20·88	0·2684	3·415	3·725	·2927
7·00	5320	210	72338·0	102·879	165·34	329·61	45·008	612·06	444·71	0·2638	1685·70	51·96	0·2648	3·369	3·776	·2967
7·25	5510	217·5	74921·5	106·553	166·77	332·19	45·108	612·40	443·58	0·2553	1737·66	51·72	0·2563	3·261	3·902	·3066
7·50	5700	225	77505·0	110·228	168·15	334·67	45·203	612·72	442·49	0·2473	1789·38	51·41	0·2483	2·159	4·027	·3165
7·75	5890	232·5	80088·5	113·902	169 50	337·10	45·296	613·04	441·43	0·2398	1840·79	51·17	0·2408	3·064	4·152	·3263
8·00	6080	240	82672 0	117·576	170·81	339·46	45·386	613·34	440·40	0·2328	1891·96	50·84	0·2338	2·975	4·277	·3361
8·25	6270	247·5	85255·5	121·350	172·10	341·78	45·475	613·64	439·38	0·2261	1942·80	50·64	0·2271	2·890	4·403	·3460
8·50	6460	255	87839·0	124·924	173·35	344·03	45·560	613·94	438·39	0·2199	1993·44	50·41	0·2209	2·811	4·527	·3558
8·75	6650	262·5	90422·5	128·595	174·57	346·23	45·643	614·22	437·43	0.2140	2043·85	50·10	0·2150	2·736	4·651	·3655
9·00	6840	270	93006·0	132·273	175·77	348·39	45·725	614·50	436·49	0·2084	2093·95		0·2094	2·665	4·775	·3753

(TABLE CONCLUDED.)

Pressure in				Temperature.		Quantity of steam converted into work during the production of steam.	Heat of steam.	Latent internal heat.	Values of n.	Values of $\frac{n}{d}$.	Differences.	Volume.		Density.	
Atmospheres.	Millimetres of Mercury.	Inches of Mercury.	Kilogrammes per square metre.	Lbs. avoirdupois per square inch.	Centigradial. t	Fahrenheit.	s	ρ				Volume of one kilogramme of steam in cubic metres. a	Corresponding volume of 1 lb. avoirdupois in cubic feet.	Weight of 1 cubic metre in kilogrammes. λ	Corresponding volume of 1 cubic foot in lbs.
9·25	7030	277·5	95589·5	135·947	176·98	350·49	614·78	435·56	0·2032	2143·85	49·50	0·2042	2·598	4·897	·3848
9·50	7220	285	98173·0	139·622	178·08	352·54	615·05	434·67	0·1981	2193·56	49·71	0·1991	2·534	5·023	·3947
9·75	7410	292·5	100756·5	143·266	179·21	354·53	615·31	433·78	0·1934	2242·94	49·38	0·1944	2·474	5·144	·4043
10·00	7600	300	103340·0	146·970	180·31	356·56	615·57	432·91	0·1889	2292·16	49·22	0·1899	2·416	5·266	·4138
10·25	7790	307·5	105923·5	150·644	181·38	358·48	615·82	432·07	0·1845	2341·25	49·09	0·1855	2·360	5·391	·4237
10·50	7980	315	108507·0	154·319	182·44	360·39	616·07	431·23	0·1804	2390·03	48·78	0·1814	2·308	5·513	·4333
10·75	8170	322·5	111090·5	157·993	183·48	362·26	616·42	430·41	0·1765	2438·62	48·59	0·1775	2·259	5·634	·4428
11·00	8360	330	113674·0	161·667	184·50	364·10	616·55	429·61	0·1727	2487·01	48·39	0·1737	2·210	5·757	·4524
11·25	8550	337·5	116257·5	165·341	185·51	365·92	616·79	428·81	0·1691	2535·11	48·10	0·1701	2·165	5·879	·4620
11·50	8740	345	118841·0	169·016	186·49	367·68	617·01	428·04	0·1657	2583·18	48·07	0·1667	2·121	5·998	·4714
11·75	8930	352·5	121424·5	172·690	187·46	369·43	617·34	427·27	0·1624	2631·00	47·82	0·1634	2·079	6·120	·4810
12·00	9120	360	124008·0	176·364	188·41	371·14	617·46	426·52	0·1592	2678·66	47·66	0·1602	2·039	6·242	·4905
12·25	9310	367·5	126591·5	180·038	189·35	372·83	617·68	425·78	0·1562	2726·08	47·42	0·1572	2·000	6·361	·4999
12·50	9500	375	129175·0	183·713	190·27	374·47	617·90	425·06	0·1533	2773·38	47·30	0·1543	1·963	6·481	·5093
12·75	9690	382·5	131758·5	187·387	191·18	376·12	618·11	424·34	0·1504	2820·47	47·09	0·1514	1·927	6·605	·5191
13·00	9880	390	134342·0	191·061	192·08	377·74	618·32	423·63	0·1477	2867·32	46·85	0·1487	1·892	6·725	·5285
13·25	10070	397·5	136925·5	194·735	192·96	379·33	618·53	422·94	0·1451	2914·11	46·79	0·1461	1·859	6·845	·5379
13·50	10260	405	139509·0	198·409	193·83	380·89	618·73	422·25	0·1426	2960·66	46·58	0·1436	1·827	6·964	·5473
13·75	10450	412·5	142092·5	202·084	194·69	382·32	618·94	421·59	0·1402	3007·22	46·53	0·1412	1·797	6·982	·5506
14·00	10640	420	144676·0	205·758	195·53	383·95	619·14	420·91	0·1378	3053·89	46·17	0·1388	1·766	9·305	·5662

the temperature from t to t_1, will be

$$Q = M(q_1 - q) + m_1 \rho_1 - m \rho.$$

By substituting for the values of q, q_1, and m_1, those given by equations (10) to (12), we shall have

$$Q = M c (t_1 - t) + m u \left(\frac{\rho_1}{u_1} - \frac{\rho}{u}\right).$$

Supposing, now, Q_0 to denote the quantity of heat that passes through the boiler in every unit of time, we shall have for τ minutes during which the temperature rises from t to t_1, and the pressure from p to p_1:

$$\tau = \frac{Q}{Q_0} = \frac{1}{Q_0}\left[M c (t_1 - t) + m u \left(\frac{\rho_1}{u_1} - \frac{\rho}{u}\right)\right], \quad . (13.)$$

By this equation the problem is completely solved. It is obvious that the coefficient $M c (t_1 - t)$ will represent a much larger number than $m u \left(\frac{\rho_1}{u_1} - \frac{\rho}{u}\right)$, the weight of the water in the boiler being always by far larger than the weight of steam therein. The increase of the temperature $t_1 - t$, will therefore be proportionate to the time τ, as has been confirmed by the investigations of Mr. Fairbairn, and lately by Prof. Von Burg, of Vienna, in his paper "On the Efficacy of Safety Valves."* The formulæ given heretofore also coincide with the results of Mr. Fairbairn's experiments.

We shall illustrate the above by a numerical example. Supposing a steam boiler to have a heating surface of 18 square metres, (194 square feet,) and a capacity of 11 cubic metres, (388·5 cubic feet,) these dimensions will correspond to those of a boiler for an engine of about 15 H. P. This boiler will yield 7·5 kilos. (16·5 lbs. avoirdupois) of steam per minute, by the usual heating process. Supposing the average pressure of the steam to be four atmospheres, (58·788 lbs. per square inch), the temperature of water and steam will be = 144° C. = 291·20° F.

In order to generate steam at a constant pressure, we must supply to each kilogramme of feed water of 0° C. introduced in the boiler a quantity of heat

$$J + A p u = 607·06 + 43·49 = 650·55 \text{ units of heat.}$$

At the moment the temperature of water reaches 15° C., the quantity of heat to be supplied will be

$$650·55 - 15 = 635·55 \text{ units (calories).}$$

The boiler yielding 7·5 kilos. of steam pr. 1″, the quantity of heat to be supplied to the boiler pr. 1″ will be

$$Q_0 = 7·5 \times 635·55 = 4766·62 \text{ calories.}$$

Supposing, now, the egress of the steam to be stopped, while the same quantity of heat, Q_0, continues to be supplied to the boiler by means of the heating process, the question arises in what time the pressure of four atmospheres will have increased to eight atmospheres, provided six-tenths of the capacity of the boiler be filled with water,

* See "Sitzungsberichte der Wiener Akademie," vol. xlv, page 313.

and four-tenths with steam of four atmospheres, at the moment the egress of steam is interrupted.

The capacity of the boiler being $V = 11$ cubic metres, the weight of the water it contains will be

$$0{\cdot}6 \times 11 \times 1000 = 6600 \text{ kilos.}$$

By the table, the weight of a cubic metre of steam at four atmosphere pressure is $= 2{\cdot}237$ kilos.; therefore

$$m = 0{\cdot}4 \times 11 \times 2{\cdot}237 = 9{\cdot}84 \text{ kilos.}$$

The aggregate weight of water and steam combined will be, therefore,

$$M = 6600 + 9{\cdot}84 = 6609{\cdot}84 \text{ kilos.}$$

The coefficients of formula (13) will be, for the original pressure of four atmospheres,

$$t = 144°;\ u = 0{\cdot}4461;\ \frac{\rho}{u} = 1034{\cdot}62;$$

and for a pressure of eight atmospheres,

$$t_1 = 170{\cdot}81;\ \frac{\rho_1}{u_1} = 1891{\cdot}96.$$

Substituting these values, we have

$$M\, c\,(t_1 - t) = 181{,}179{\cdot}2$$

$$m\, u \left(\frac{\rho_1}{u_1} - \frac{\rho}{u}\right) = 3763{\cdot}3;$$

and as $Q_0 = 4766{\cdot}62$, we find

$$\tau = \frac{181{,}179{\cdot}2 + 3763{\cdot}3}{4766{\cdot}62} = 38{\cdot}80 \text{ minutes;}$$

i.e., in a boiler worked under the above conditions, the pressure of steam will require 38·8 minutes to rise from four to eight atmospheres.

Supposing, on the other hand, the volume of water in the boiler to be less than that of the steam, at the moment the egress of the latter is stopped, say, *e.g.*, the proportion to be water : steam :: 0·4 : 0·6, the weight of the steam would be

$$m = 14{\cdot}76 \text{ kilos.,}$$

and water and steam combined

$$M = 4414{\cdot}76 \text{ kilos.;}$$

and to raise the pressure from four to eight atmospheres, we should then require a lapse of time

$$= 26{\cdot}57 \text{ minutes,}$$

i.e., 12·23 minutes less than in the former instance.

The following table exhibits the values of the several coefficients for the same boiler, for pressures varying from four to twelve atmospheres.

This table shows that the inference drawn by Councillor von Burg from Mr. Fairbairn's experiments, viz: that the temperature in the boiler increases in proportion to the time, is perfectly justified. The speed with which the pressure in a closed boiler increased will depend on the quantity of water in the same; the less water there is, the more

the pressure will increase, and with it the liability to explode. All this corroborated Bernouilli's opinion, that the quantity of water in the boiler is the real standard of the pressure of the steam.

Pressure in Atmospheres.	Temperature in degrees Centigrade.	Differences, $t_1 - t$.	Volume of Water in the Boiler.			
			0·6 v.		0·4 v.	
			Lapse of time τ''.	Differences.	Lapse of time τ''.	Differences.
Original 4	$t = 144{\cdot}00$	. .	. .	. .	. .	. .
5	$t_1 = 152{\cdot}22$	8·22	11·86	11·86	8·09	8·09
6	159·22	15·32	21·97	10·11	15·01	6·92
7	165·34	21·34	30·85	9·88	21·11	6·10
8	170·81	26·81	38·80	7·95	26·57	5·46
9	175·77	31·77	46·02	7·22	31·55	4·98
10	180·31	36·31	52·64	6·62	36·12	4·57
11	184·50	40·50	58·76	6·12	40·36	4·24
12	188·41	44·41	64·48	5·72	44·32	3·96

Mont Cenis Tunnel.

From the London Practical Mechanic's Journal, August, 1865.

Pending the completion of the tunnel of $7\frac{1}{2}$ miles through Mont Cenis, and which, as more than $4\frac{1}{2}$ miles remain to be pierced, will yet require seven or eight years, Messrs. Brassey have taken steps towards the construction of a railway over the mountain, to supply the break of 47 miles now existing between St. Michel and Susa in the line of communication between France and Italy. The French government have promised a concession for the work on their side of the mountain, on the condition of its practicability being demonstrated, and the Italian government have undertaken to grant what is required on their side. An experimental line has accordingly been already constructed on the French side between Lanslebourg and the summit—a distance of a mile and a quarter—and Captain Tyler, of the Royal Engineers, was recently deputed by the Board of Trade to visit it and report the results. That report has now been printed, and its conclusions are of a very favorable character. It describes the experimental line to possess a mean gradient of 1 in 13, and a *maximum* of 1 in 12. It passes round a sharp corner, joining two of the zigzags of ascent on a curve with about two chains radius, and was purposely constructed on the most difficult portion of the route. Captain Tyler, in two days, took six trips with the engine up and down, carrying each time a load of 16 tons in three wagons, including the weight of the wagons, and it performed the ascent in $8\frac{1}{2}$ minutes. Mr. Fell,

by whom the work has been carried on under estimates framed by Mr. Brunlees, C. E., has thus "shown practically that gradients of 1 in 12 to 1 in 15 may, by a system of horizontal driving wheels acting upon a middle rail, be substituted for 1 in 25 and 1 in 30, which have hitherto been practicable, and that sharper curves may also by this system be more safely worked," or, in other words, "that a railway may be constructed over a given summit of half the length that would otherwise have been necessary, and at less than two-thirds the cost." In the present case, the cost of the temporary line is to be £320,000, or about £6720 per mile, whereas the tunnel line is expected to cost £5,400,000, or £128,500 per mile. Even the cost of a permanent and independent summit line, with a wider gauge and better curves, would not exceed £20,000 per mile. The importance of these results to the future of railway construction in mountainous countries can therefore hardly be over-estimated. No pecuniary aid has been asked either from the French or Italian governments, Messrs. Brassey feeling certain of a sufficient profit from the natural traffic at the tariff which has been provisionally sanctioned. The road traffic between the two points yielded, in 1864, £76,000, and it steadily increases at the rate of more than 10 per cent. per annum. This, without estimating any higher rate of increase after the opening of the railway, would yield in seven years a total revenue of £1,080,000, and "it is considered that such a revenue would leave at the end of that time a clear profit of seven millions of francs, after deducting all charges, and after paying interest upon and paying off the total bond and share capital of £320,000. But as the great saving of time, combined with the agreeableness of the passage, would inevitably promote a great accession of travel, and it is calculated, moreover, that 38 hours may be saved by this work in the transmission of the Indian mail, prospects much more gratifying may fairly be assumed. "In conclusion," Captain Tyler states, "I have to report as the results of my observations and experiments, that the scheme for crossing the Mont Cenis is in my opinion practicable, both mechanically and commercially, and that the passage of the mountain may thus be effected not only with greater speed, certainty, and convenience, but also with greater safety than under the present arrangements."

On Marine Engines from 1851 *to the Present Time.*

By N. P. Burgh, Esq., Engineer.

From the Journal of the Society of Arts, No. 643.

The history of the origin of the marine engine, and its slow advance, has been so often written, that I feel assured I shall not cause much disappointment if I pass over that already worn-out subject. I propose, therefore, to introduce to your notice the marine engine as it was in 1851, and the improvements which have taken place from that period to the present time. As the present paper alludes to the year

1851, it will not be deemed out of place to describe briefly the marine engines shown in the Exhibition of that date. The screw propeller was then making but slow progress, consequently the attention of our engineers was diverted from straining their talents to produce more perfect arrangements. The following examples of marine engines were exhibited:

For the paddle-wheel, the engines were arranged as follows: Vertical, angular or inclined, direct-acting, and oscillating; for the screw propeller, a more varied and numerous collection was given, comprising disk, rotary; for horizontal direct-acting types, were the following: double piston rod, return connecting rod, trunk; after which, annular cylinder, vertical direct-acting, inclined direct-acting, single piston rod; and lastly, a beam engine. The largest pair of engines were 700 horse power collectively, horizontal, direct-acting, single piston rod. The trunk engines were 60 horse power collectively; these two examples were adapted for the screw. For paddle-wheels, the engines of the greatest power were a pair of 140 horse power, of Belgian repute, the framing and paddle-centres being of wrought iron, thus ensuring sufficient strength with a reduction of material and weight. To describe each engine in detail would be tedious, as well as of little value to the engineer of the present day. Allusion to the defects and improvements will be found under the different descriptions of the necessary appendages.

I now proceed with a brief notice of the marine engines exhibited in the year 1862, when it will be seen that a great improvement had taken place between the two dates alluded to. We are, I am happy to state, still making an advance, and I trust to be able this evening to describe these improvements; but, at the same time, I beg to suggest that there is plenty of room for further improvement in the detail of marine engines, which, doubtless, will be ere long taken into consideration by those interested in these matters.

In the year 1862, our International Exhibition was again held, and with much success as far as regards marine engines. The class exhibited showed great improvement, both in design and arrangement. The oscillating engines adapted for the paddle-wheel did not exhibit much alteration, although it cannot but be said that in detail a change for the better was perceptible. With reference to the engine adapted for the screw, a complete revolution had taken place since the Exhibition of 1851. Valves and gear were altered, starting gear simplified; position of condensers, air pumps, and valves, in a much more correct state; number of details lessened; and, in fact, the entire arrangement fast approaching to a nearer state of perfection, viz: accessibility to all the parts in action without disarrangement. The following is a brief account of the writer's observation of the class of marine engines exhibited: The paddle engines were vertical and inclined, oscillating, of the ordinary type and arrangement. The valve gear was of two kinds—the counter-balanced eccentric, and the ordinary link motion. The air pumps were worked by eccentrics in some instances, and in others by cranks. The mode of starting was by the

ordinary ratchet or wheel and pinion—the bilge and feed pumps were, in some cases, worked by the oscillation of the cylinder, and in others by eccentrics. The means for disconnecting were of the disk and the drag-link kinds. Paddle-wheels were exhibited with fixed and feathering floats. Five examples of oscillating engines were exhibited, including models and drawings. The engines for the screw propeller were as follows: One pair of double trunk engines, having injection condensers with an improved arrangement of air-pumps and valves. The double piston rod, return connecting rod type was well represented; this arrangement is used on account of the great length of stroke and connecting rod attainable in a given space. In the Exhibition now alluded to there were six pairs of engines of this class, with injection condensers and air pumps of the ordinary arrangement, and one pair of engines with the improved arrangement of condensers, pumps, and valves. The single piston type of engine was not largely represented—one pair with the improved injection condenser, pumps, and valves, and one pair with those of the ordinary kind. The single trunk arrangement was represented by one pair, with single acting trunk air pumps in the condensers. The air-pump trunk with double piston rods return connecting rod engine was shown by drawings only. Vertical direct-acting engines were represented thus—one pair with annular cylinders, double piston rods, and injection condensers of the ordinary kind; one pair with single piston rods and surface condensers; and another pair as the last, with ordinary condensers.

It will be understood that in the previous examples the cylinders were arranged in pairs, the cranks being at right angles. In order to obviate the strains imposed at the extremity of each stroke, one firm exhibited engines with three cylinders, with spur gearing for reversing, stopping, &c., which were termed the expansive and economical principle. Lastly, I allude to the writer's invention "Burgh and Cowan's patent antifriction trunk engine," so arranged, that the friction of the trunks is dispensed with, and no area lost in the cylinder. This arrangement was represented by a pair of engines and drawings. Having thus briefly alluded to the marine engines exhibited in the two International Exhibitions of 1851 and 1862, I will now proceed to give a detailed description of each portion.

The arrangement of marine engines in the hold of the ship is, perhaps, not generally thought to be of so much importance as it really is. It should be strictly understood that the attention required for engines of river steamers bears no comparison with that required for marine engines. Imagine a ship in a gale, and heated bearings, and a faint idea can be formed of the duties required, and the reason for a free access to all the working parts.

For the purpose of illustration to those present, not professional engineers, I will briefly specify what the necessary component parts of a pair of marine engines of the present day consist of, viz: cylinders, pistons, slide valves, piston rods, slide casings, expansion valves, blow-through valves, piston rod guides, connecting rods, cross-heads, main frames, crank-shaft, eccentrics, rods, links, valve rods, guides,

condensers, air pumps and valves, injection valves, shifting valves, discharge valves, bilge and feed pumps, valves for the same, starting gear and turning gear, lubricators, and all the necessary levers, bolts, nuts, &c. It will thus be seen that marine engineers have more difficulties to contend with than is generally known. To understand the use and real character of each of the above details is not the work of weeks or months, but years. It should not be forgotten either, that the honor of our nation, and the lives of its representatives, are often in the hands of the marine engineer. I will now proceed with the descriptive illustration of details, showing defects, improvements, and suggestions for the future, commencing with slide valves.

These valves govern the entrée and exhaust of the steam to and from the cylinders. Two kinds or classes of valves are now universally used, the common and the equilibrium; the former is so well known that a description of it is scarcely necessary. I will only observe that its use for larger engines is much on the decrease, on account of the stroke of the valve being due to its outside lap, which for large ports is considerable. Equilibrium valves are so called from the equal action of the steam tending to lift the valve from, as well as to press it on its facing. These valves are double ported to reduce the stroke. One firm has lately introduced three-ported valves, to still further reduce the stroke. In order to reduce the friction of the valves on the facings, rings are used encircling the body of the valve, adjustment being gained by screws, ratchets, and springs to prevent looseness. In some cases a communication from the back of the valve to the condenser is arranged to still further reduce the pressure on the valve facing. Slide rods are usually one to each valve, but latterly two have been introduced for large valves, which no doubt greatly assist in guiding the valve during its action.

The next portion in rotation will be that for working, reversing, and stopping the action of the slide valve universally known as the "valve link motion." The date of the origin of this motion is doubtful. Mr. Zerah Colburn, in his new work on locomotive engineering, tells us, however, that 1832 is the earliest period of its application for locomotives. Marine engineers introduced it first for oscillating paddle wheel engines; afterwards for fixed, horizontal, and vertical engines adapted for the screw propeller. The object of the link motion is to reverse the action of the slide valve without disconnexion. The links now in use are of two kinds—slotted and solid. The slotted link has the sliding block within it, whereas that of the solid kind slides within the block. The means adopted for raising and lowering the link are various. One maker prefers to use a lever, secured on a weigh-shaft, passing over the front part of the cylinders, motion being given by a worm and wheel, the former being keyed on or forming part of the starting wheel shaft. Another firm deems it better to impart motion to the lever by a ratchet and pinions. A third authority raises and lowers the link by a rod connected to a block surrounding a coarsely pitched screw, motion being given to the screw by mitre gearing; whilst another firm prefers to fix the block, with the screw

to be elevated and lowered. These two last are undoubtedly the most powerful of the examples given.

The systems at present adopted for guiding the slide valve rod are of three kinds. First, the dove-tailed guide, similar to that used by tool makers for the arm of a shaping machine. Second, a block of gun metal sliding on two fixed turned rods as guides over and under the valve rod. Third, the valve rod secured to a square bar, working in a bracket, and cap to correspond. This last may be said to be the most simple, but perhaps not so rigid as the first example. The double guides are complicated, but at the same time produce the rigid resistance to the strains imposed on the valve rod by the vibration of the link.

Some makers of marine engines prefer to allow the link to rest or hang on the block pin inserted in the lever of the slide rod weigh-shaft. Such a practice dispenses with guides. Excessive vibration of the link on or in its block greatly deteriorates the action of the valve, it being understood that whilst the link has an ascending or descending motion, as well as sliding, the strain on the valve rod is increased, and at the same time the stroke is effected. The excess of the vibratory motion is painfully perceptible in the ordinary slotted link; the eccentric rods being connected beyond the block pin, a direct-action cannot ensue. The distance between the centres of the eccentric rods and block regulates the amount of indirect action. Links of this kind are often hung from a rod connected in the centre to the link, either to the clip or at the back. This is far better than at the lower end, as the connexion of the suspension rod regulates the ascending and descending motion of the link whilst at work. The link resting on the block when for going ahead, obviates to a certain extent some of the evils alluded to. The gain by the introduction of the solid link, with the eccentric rods connected at its extremities, is strength with less material, but the vibrating motion is not decreased. In order to obtain a more direct, and, if possible, a perfect action, the eccentric rods have been secured to the link, so that the centre of connexion may be on that of the block, and by this the vibratory motion is effectually got rid of. There have been two distinct modes for accomplishing this, which I have had the opportunity of observing. The first example is—two solid links, one on each side of the block, the eccentric rods being connected to pins on the outer face of each link, the inner face and sides being sustained in a groove in the block, which oscillates on its axis, in the eye of the valve rod, the links being one on each side. The second example is like the first in principle, but one solid link only is used, of a dove-tailed form in section, at the inner face, to prevent the link from slipping out of the groove in the block; the eccentric pins are fixed in the extremities of the link, and the rods are attached as in the last example, but with a single eye. The writer has designed a solid link and connexion, which, although not superior in principle of action to the two last examples, is more simple in construction, and has less working portions; therefore it may be held to be worthy of introduction. A solid bar of iron is slotted

at each end, to receive the single eye of each eccentric rod, so that the entire surface of the link remains unbroken; it is secured in a block with an adjusting portion and key at the back, the front being open sufficiently to admit of the ascent and descent of the eccentric rods; adjustment in front can be obtained by loose portions and set-screws, but this last is not imperative, as the wear of the link and block is very slight when the acting eccentric rod is on the centre of the block; the block has provisions on each side for suspension, the valve rod having portions formed to receive the block; the back part of the rod works in a dove-tailed guide of the ordinary kind.

It now becomes necessary to treat of the suspension or lifting rods for solid links; for this a few words will suffice. As the ascent and descent of the link whilst in motion are governed by the length and position of the rod, it is almost needless to state that the suspension rod should be connected in the centre of the connexion of the eccentric rod. The link, when for going ahead, should be down. It may now be argued that the vibration of the link, when for going astern, must be excessive. Granted; but as the forward motion of the ship is of the most importance, it is not unfavorable to economy to adopt the connexion alluded to. In some cases the solid link is guided at the top or bottom, but this is only required when an overhanging or outside connexion of the eccentric rods is resorted to.

The next portion for consideration is the expansion valve and gear; the use of this valve is to allow the steam to be cut off at the early or given part of the stroke of the piston, and the expansion or elasticity of the steam completes the power required. Now, it is certain that the use of high pressure steam for large cylinders and short strokes, produces excessive shocks at the commencement of the strokes, and thereby entails an increase of strength in the materials used, so that the proportions are larger than when for ordinary purposes. It is clear also that, when steam is admitted at an excessive pressure against the piston suddenly, it (the piston) receives an impetus equivalent to the power imposed, and in no case whatever could an engine of proportions for low pressure resist the strains imposed by the use of high pressure steam. The ordinary pressure adopted by marine engineers is from 20 to 30 lbs. per square inch, more often the former than the latter. I am not aware, however, of any cause why 60 to 80 lbs. should not be adopted, with a great increase of economy and power. Of course, the present proportions of engines and boilers would have to be increased, if the same materials were used, but steel boilers, shafts, and rods might be introduced with considerable advantage, embracing great strength with less weight.

Having alluded to the ordinary pressures at present used, it will be well now to advert to the expansion valves. These valves are of three kinds—throttle, slide, and tubular.

The motions imparted to the throttle valve are oscillating and revolving. The latter is now most generally adopted, but with this disadvantage, that the action is equal both for supply and cutting off.

The slide valves are of the ordinary and gridiron type, the latter may

be said to be the better on account of the stroke being so short in comparison to that of the former.

Tubular valves are tubes inserted in each other, with ports to correspond, a sliding or rotary motion accomplishing the desired effect. The motions imparted to these several valves are generally uniform, either by mitre gearing or eccentrics, consequently the action of the valves is not perfect. The proper motion for an expansion valve is to open gradually and close suddenly; to obtain this the old but correctly working cam must be resorted to; this useful arrangement is too often discarded to make place for newer but less correct productions. It may, of course, be urged that the cam is not applicable for high velocities, but undoubtedly its use might be attained by introducing stiff gear and perfect equilibrium double beat valves; by dividing this valve centrally a more correct action can be attained, in relation to that of the steam, on the valve whilst closed and open. The merits and demerits of the expansion valves here alluded to are almost equal. The ordinary throttle valve has less friction than any yet introduced, but it possesses the great evil of throttling the steam when closing; also when this valve is worked by levers, or has a vibratory motion, should the stroke be lessened, the full area cannot be attained. The last evil is dispensed with in the remaining example, as the ports or openings are much larger than required when the valve is at full stroke, and not too small when the least motion is given. The friction of the grid-iron valve is perhaps in excess of the other examples, as in the case of the tubular valves, the action of the steam is neutralized. The means adopted for altering the grades of expansion valves whilst in motion are various. A spiral motion is the one universally adopted, and there is not the least doubt it is correct.

I will now call attention to the following description of an expansion valve and gear which I have designed for high velocities: A cylindrical casing has within it projections at given positions; two of these projections act as spaces between the ports of ordinary tubular valves. The valve now explained is tubular, but the area centrally is half of that of the ends, which are parallel for given lengths, due to the stroke of the valve. These parallel lengths also regulate the neutrality of the valve whilst in action. At the present time the means adopted to impart the motion is a disk of metal with a circular slot; within this slot is a brass nut into which is screwed a pin. The connecting rod of the valve is attached to the pin in the ordinary manner. The means for altering the grades of expansion is by loosening the pin by its handle, and allowing the nut to slide in the slot to the required position. It is almost needless to add that the steam enters at the side of the casing, and escapes around and through the valve, keeping it in equilibrium.

The valves next in requisition are those for the ends of the cylinder, commonly known as relief valves. The usual kinds adopted are disks, with springs or weights to resist the given pressure of the steam. The action of these valves is, of course, due to the excess of pressure within the cylinder over that of the resistance caused by the springs or

weights. It has been proved that in the case of excessive priming of the boilers, the cylinders are suddenly flooded; in order to release the water, cocks are sometimes used, but in many instances the springs or weights are lifted by levers. Now, in the case of cocks, if not provided with valves beyond them they must be worked by hand at each return stroke of the engine, or the vacuum will be destroyed. The spring valves will close naturally, or by the spring on its release from the hand lever. High pressure steam has been lately introduced, with great advantage, in the place of springs, but with an entirely differently arranged valve and casing.

I have arranged a relief valve, so that the spring is not tampered with by levers or hand power, and an instantaneous opening can be effected without cocks, &c. The spring valve has an opening in it centrally to receive on its outer side a flat disk, termed the vacuum valve. On the inner side is a provision mitred to receive a solid disk valve, which, on being pressed inwards by a spindle and lever, allows a free exit for the steam and water. On a vacuum being caused the vacuum valve, which is guided on the spindle alluded to, closes the opening air-tight; by this it will be understood that the spring has not been in requisition, but on closing the inner disk the spring valve becomes one of the ordinary kind. Previously to starting the engines it is well known a vacuum should be caused in the condensers, also the cylinders and slide casings should be warmed, and the condensed water be allowed to escape through the relief valves and cocks.

The valves used for the purpose alluded to are termed the "blow-through valves." It may be here observed that, in some cases, the ordinary plug-cock is preferred for this purpose. When valves are introduced, they are generally of the ordinary disk kind, but one firm adopts a common slide valve for the purpose, with the advantage of simplicity of levers, &c., and easy manipulation.

The piston rods of marine engines are subject to excessive strain; consequently, the use of guides is imperative. For the single piston rod engine, the universal system is a channel underneath the rod, the guide block being generally of gun metal, and the upper portion attached to the piston rod by bolts and nuts. For double piston rod engines, the guides are of two kinds: the first arrangement is as the last, and the second, as for high pressure engines, or double guides. To say which is the preferable mode of arrangement of guides will perhaps be deemed bold, but I may venture to state that I deem that for the single piston rod the best of any yet introduced.

I cannot close this portion of the present paper without alluding to the admirable arrangement for tightening the gland of the piston rod stuffing boxes, introduced by the firm of Messrs. Maudslay, Sons & Field. The screws are of the ordinary kind, but, in the place of nuts, worm wheels are used, worms being fitted to correspond; and motion can be given by a box spanner while the engines are at work. This is one of the most important improvements tending to accelerate the progress of a ship during a voyage, say three or four months. Imagine the engines requiring stoppage during a gale in order to tighten

the glands, and a fair estimation can be formed of the value of the improvement alluded to.

Having commented, though somewhat briefly, on the cylinder appendages, attention may now be given to the main frames and crank shaft. The main frames may be said to undergo a continuous strain, and must, consequently, be of a certain strength in order to preserve the requisite rigidity. The cylinder is attached to the one end, and the condenser at the other, whilst the crank shaft has to be supported in its bearings. Not many years ago a celebrated firm used to make the condenser and main frame in one casing: since that, we have had the well known frame like the letter A laid on its side, also the hollow frame, with a raised projection for the crank shaft, and a stay from the upper portion connected to the cylinder; this last may be said to be the most simple, and, at the same time, of less material than the A frame. As before stated, the strains on the frames are continuous, yet, when sudden shocks occur, from the racing of the engines or priming of the boilers, the tenacity of the cast iron is severly tested. As this is the case, wrought iron might be used with great advantage, both as to increase of strength and decrease of weight. The crank shafts of marine engines are generally of wrought iron, in one mass, the cranks being double, and forged with the shafts. Three bearings are deemed imperative, so as to equally distribute the strains. Now, this is correct in theory and practice, and the writer will be deemed committing a grave error no doubt in mathematics, when he assumes that the forward frame and half crank can be dispensed with, in order to reduce the weight and material. He is, of course, aware that the thrust and pull of the connecting rod will be thrown on the centre crank and bearing, but, in order to counteract this, the length and diameter of the shaft at that part should be increased. He would also prefer, in this case, to extend the frame and connect the upper portion to the condenser, the cap being on the top instead of at the end, as now used. Screws might be employed to adjust the side brasses; the eccentrics could be within the cranks, or between them and the bearings.

(To be continued.)

Roof of the London Terminus of the Midland Railway.

From the London Mechanics' Magazine, June, 1865.

Up to the present time the roof of the Imperial Riding House, at Moscow, has held its place as the largest ever executed, its span being 235 feet. But we understand that it is contemplated to cover in the London terminus of the Midland Railway with a roof of wrought iron 240 feet clear span. It will be of an arch construction, springing from the level of rails, and having a versed sine of about 100 feet. When built, this roof will, therefore, rank as the largest of one span in the world.

Prevention of Railway Collisions.

From the London Athenæum, June, 1865.

Under the excitement caused by recent railway accidents, in one of which literature only just escaped from a fearful loss, the traveling public will learn with much satisfaction that an experienced officer of the London and North Western Railway has adapted and is now carrying out a plan by which it is hoped that collisions, at least, may be prevented. This officer is Mr. S. M. Martin, the Telegraphic Engineer of the Company; and his plan consists, mainly, in establishing a series of permanent currents of electricity in connexion with the telegraph by which an interval of space may be secured between trains traveling in the same direction. At every station, level crossing, and siding, there are telegraphic instruments by which a signal man may be informed of the approach of every train in either direction. Nothing is left to the signal man's memory, capacity, or discretion. The telegraph puts the fact before him on the dial. He has only to read and act. To make the matter perfectly easy, only three signals are used, namely, "Train on line," "Line clear," "Line blocked." So long as a train is approaching a station, the signal "Train on line" is permanently indicated on the dial before the officer's eyes. In the event of a train coming to a stand-still between any two stations from any cause, it is the duty of the guard, or other person in charge of the train, to leap down and sever the current wire, which is conveniently placed within his reach at every second post. The permanent current being stopped, the signal man is made aware of it by his dial reporting "Line blocked." Measures may then be taken accordingly. It is stated that this plan is so simple that no previous instruction is required in order to work it. Anyhow, it is clearly a plan which deserves attention from all railway directors and officers; all the more from the fact that it is already in operation over the major portion of the London and North Western line.

New Steam Engine.

From the London Mechanics' Magazine, February, 1865.

An addition has just been made to the plant of the Lambeth Distillery Brigade in a new steam fire engine, made by Merryweather, called the "Ocean Wave," which is perhaps the most powerful machine of the kind in the world. The weight is $2\frac{1}{4}$ tons, and it is said to get up steam in eight minutes, and to discharge six jets of water to a distance of 220 feet.

New Zealand Coal Mines.

From the London Mechanics' Magazine, February, 1865.

In the province of Auckland, New Zealand, mines are being worked which yield a coal of superior character to English coal. It requires one hour forty-five minutes to raise steam by means of the best New-

castle coal, whilst by that from Kawakawa mine, at the bay of Islands, in the above province, steam is stated to be raised in one hour five minutes.

Average Consumption of Coal per Horse Power.

From the London Mechanics' Magazine, June, 1865.

The present average consumption of coal in Her Majesty's steamers is 3·5 lbs. per indicated horse power per hour, but with the improvements recently effected in the machinery of the "Arethusa," the "Octavia," and the "Constance," (which improvements have in view the obtaining of correct data with regard to the comparative consumption of coal,) confident anticipations are formed that the consumption will be one-third less, or 2·5 lbs. per actual horse power per hour.

MECHANICS, PHYSICS, AND CHEMISTRY.

On Chemistry Applied to the Arts. By Dr. F. Crace Calvert, F.R.S., F.C.S.

From the London Chemical News, No. 244.

(Continued from page 194.)

Lecture IV.

Animal Fatty Matters, the various processes for liberating them from the tissues in which they are contained. Their composition and conversion into soap. Composite candles. The refining of lard. *Cod liver*, *Sperm*, and other oils. *Spermaceti* and *wax*.

I have now to draw your attention to a totally different kind of manufacture, viz: that of composite, stearic, and Belmont candles. Many years elapsed between the scientific discovery by M. Chevreul of margaric and stearic acids, and their application to illuminating purposes; for it was early in 1825 that MM. Chevreul and Gay Lussac took out a patent with a view of realizing this advantage. But it was reserved for a manufacturer, M. de Milly, to perfect the manufacturing details of the processes, and to render these candles a marketable commodity. This he affected by also improving the manufacture of the wicks, and he was the first to introduce this article to the trade in 1832, under the name of *bougies de l'etoile*. Let me give you an idea of his *modus operandi*. 100 lbs. of tallow, 17 lbs. of lime previously slaked, and 1000 lbs. of water were placed in a large iron boiler, and kept at the boil for several hours by means of a jet of steam. The result was that the glycerine dissolved in the water, whilst the fatty acids united with the lime. The indissoluble stearate, oleate, and margarate of lime were then decomposed by weak vitriol, under the influence of heat. Insoluble sulphate of lime was produced, and the fatty acids liberated. These, in their turn, were submitted to hot and cold pressure, which liberated the oleic acid, leaving the solid stearic and margaric acids

behind; it was then only necessary to cast them into moulds containing wicks, and the *bougies de l'etoile* were produced. MM. de Milly and Motard have introduced of late years several important improvements into this branch of manufacture, the most important of which is that of operating under pressure, by which means they succeed in decomposing the fatty matters with 3 or 4 per cent. of lime instead of 17, this, of course, involving the saving of a large quantity of vitriol. M. Bouis has made a further improvement by adding to stearic candles 3 or 4 per cent. of cebacic acid, which is extracted from castor oil, and has the high fusing point of 261 degrees. M. Chevreul also suggested a simple method of increasing the whiteness of these candles by the addition of a small quantity of ultramarine blue to neutralize the slightly yellow tint of the manufactured acid. One of the greatest improvements in the manufacture of these candles is that carried out by Price's Candle Company; but before describing to you this beautiful process, as adopted by Mr. G. F. Wilson, at this company's works, allow me to state a few facts. Up to 1840 the best kind of candles were those made of spermaceti or of animal fatty matters which were cold and hot pressed. In that year Mr. Wilson, whilst experimenting with the view of making candles which would not require snuffing, for the illumination on the occasion of her Majesty's marriage, discovered that a combination of cocoanut stearine with stearic acid would make candles giving a beautiful light, and free from the necessity of snuffing. These he called "composite," and they were soon largely sold. In 1838 M. Fremy published his interesting discoveries, showing that when oils or fatty matters were mixed with 20 or 30 per cent. of concentrated sulphuric acid, the fatty matters were split, or, as he calls it, saponified, and that sulpho-margaric, sulpho-stearic, sulpho-oleic, and sulpho-glyceric acids were formed. He further observed, that boiling water decomposed the sulpho-stearic and margaric acids, and only partially the sulpho-oleic into stearic, margaric, oleic, and sulphuric acids, which last acid remains in the water together with the sulpho-glyceric acid and that portion of the sulpho-oleic acid not decomposed, the other acids remaining insoluble and floating on the surface. In 1842, Messrs. G. Price and Jones secured a patent to carry out on a practical scale the scientific discoveries of M. Fremy. In that patent two or three important facts were brought out: First, that if, instead of operating at a low temperature, as recommended by Fremy, heat was employed, the action of the sulphuric acid on the organic compounds would give rise to sulphurous acid, which they discovered had the remarkable property of converting the liquid oleic acid into a solid acid called "eladic," thus largely increasing the yield of solid fatty acids. Their mode of operating was this: 10 to 12 per cent. of concentrated sulphuric acid was added to the fatty matters which had been previously liquefied by heat, and the whole was kept at a temperature of 200° for twenty-four hours. During that time the fatty matters were split into their primitive elements, and the oleic acid was converted into eladic acid. The whole was then repeatedly treated with boiling water, to dissolve the sulpho-glyceric acid and other impurities, leaving the solid

fats ready for distillation. Mr. G. F. Wilson has since then greatly improved this part of his manufacture, as the beautiful candles, everywhere to be seen, will amply prove. The most important improvement, in a chemical point of view, is the following: He has found, for example, that fatty matters are split up into their component parts by decreasing quantities of vitriol as the temperature used is increased. Thus, at a temperature of 100°, 15 parts of vitriol are required; at 350°, six parts; at 500, one part. Further, by employing this small proportion of sulphuric acid, not only is the expense of washing the fatty matters after their saponification by the acid avoided, but the distillation may be proceeded with in the same vessel. The distillation of fatty matters, first performed by Mr. Wilson, and since carried by him to a state of perfection, is based on the fact that, whilst fatty matters, if distilled by direct heat, are completely decomposed, giving rise to the noxious vapors of acroline, from the destruction of the glycerine, &c. This evil is completely avoided in distilling them by passing a current of superheated steam at a temperature of between 550° and 600° through the mass of melted fatty matters previously brought to the same temperature. By this means the glycerine passes first without decomposition, and is then followed by the fatty acids. In fact, the distillation proceeds with such rapidity and regularity that a stranger might witness the distillation of 1000 gallons in twenty-four or thirty-six hours, and all the time would probably suppose that water only was distilling. The results are so perfect, that the jury at the Paris Exhibition of 1855 could hardly credit their genuineness, and actually deputed Mr. Warren de la Rue to come from Paris to verify the fact that the beautiful products exhibited were obtained in many instances from very inferior kinds of fat. The glycerine only requires redistillation to be fit for all the purposes to which it is applied. As to the acids, they are submitted to an intense cold pressure, which separates the oleic acid from the stearic, margaric, or palmitic acids. These are melted, and when near the point of solidification, the vessel containing them is run on rails over the moulds, which are so arranged that each frame contains 200 separate moulds, in which already the wicks, prepared with borax or a salt of ammonia, are fixed. The only remaining operation is to fill the moulds and allow the candles to cool.

Oleic acid has recently been made available for several valuable purposes. It has been largely employed in the manufacture of soap; but its most important application as yet is its use on the Continent, and recently in England, as a substitute for olive oil in the greasing of wool for spinning, the advantages of which are marked, as its removal by alkalies in the scouring process is much easier and its price lower. Messrs. Laing and Wilson have recently taken out a patent for the employment of oleate of ammonia as a mordant; and, as the specimens which I have the pleasure to show you illustrate, it increases in a marked manner the beauty and brilliancy of the coal tar colors on cotton.

It now only remains for me to refer to another interesting process for splitting fatty matters into their elements, I mean that of M. Tilgh-

man, which consists in mixing fatty matters with one-third to one-half of their bulk of water, and placing them in a vessel capable of resisting a very high pressure. They are submitted to a temperature of between 550° and 600° Fahr., and under the influence of that heat and pressure the fatty matters are decomposed into glycerine and fatty acids. M. Tilghman has also adapted an apparatus which enables him by means of coils of tubes to keep up a constant stream of fatty matters and water through the tubes surrounded by fire, by which means the decomposition is rapidly and continuously carried on. I must not, however, conclude this part of my lecture without drawing your attention to these beautiful specimens illustrating the manufacture of Messrs. Price & Co., kindly lent to me by Mr. G. F. Wilson.

Spermaceti.—This valuable substance is found in large quantities in the bony receptacles of the head of the white whale of the South Seas, and as it is there mixed with a fluid substance called sperm oil, these are separated by means of filtration. The solid mass which is thereby left in the linen bags is first pressed cold, and then between heated plates (hot-pressed). It is then physicked, or heated in a boiler with a solution of caustic potash of specific gravity 1·45, which dissolves a small amount of oily matter, still adhering to the spermaceti, and this after being well washed is run into moulds to cool. The manufacture of spermaceti candles requires great care and practical experience. The only fact I shall mention is, that about 3 per cent. of wax is added to spermaceti to prevent the mass being too crystalline or brittle. M. Chevreul, who chemically examined pure spermaceti, or cetine, at the beginning of this century, succeeded in unfolding it into an acid, which he called ethalic acid, very similar to palmitic, and into a neutral substance called ethal, the composition of which, he prognosticated, would be found to contain pure alcohol. This, I am pleased to say, has proved to be the case; for its composition may be considered as represented by

$$C_{32}H_{33}O_3+HO.$$

Mr. Heintz has recently published a very elaborate paper on the composition of this substance, and states that spermaceti contains the following components:

		Ethal or oxide of cetyle.
Stearophanate, .	$C_{36}H_{35}O_3$	$C_{32}H_{33}O_3$
Margarate, .	$C_{34}H_{33}O_3$	"
Palmitate, .	$C_{32}H_{31}O_3$	"
Cetate, .	$C_{30}H_{29}O_3$	"
Myristate, .	$C_{28}H_{27}O_3$	"
Create, .	$C_{26}H_{25}O_3$	"

It appears to me that several of these products do not exist ready formed in spermaceti, but are the results of chemical reactions.

Beeswax.—I have already had the pleasure, at the commencement of this lecture, of drawing your attention to the fact that bees either gather wax from the flowers on which they alight, or are capable of producing it direct from saccharine matters. The wax as it is obtained

from the honeycomb being colored, it is necessary to bleach it for most of the applications which wax receives. The old process (still followed in many parts of Europe) consists in melting wax in water, and allowing it to run into a second vessel, so as to separate it as completely as possible from its impurities. When cooled to nearly its melting point, it is allowed to fall on rollers which revolve in cold water, by which means thin ribbons of wax are obtained, which are then placed on meadows to bleach under the influence of the atmosphere. The above operations are repeated until the wax is perfectly bleached. This plan is so tedious and expensive that several chemical processes have been proposed. M. Casseraud's is, to pass steam through the melted mass, which is, at the same time, subjected to the influence of sunlight. Mr. Solly's is, to treat the melted wax by a mixture of nitrate of soda and sulphuric acid, when the nitric acid liberated oxidizes and destroys the coloring matters of the wax. Pure wax melts at 149°, and when treated with alcohol is found to be composed of

Cerine or cerotic acid, . .	$C_{54}H_{53}O_3HO$	65
Myricine, . .	$C_{92}H_{92}O_4$	30
Ceroleine, ...		5
		100

Sir Benjamin Brodie, who examined most minutely the chemical composition of a great variety of waxes, considers that the substance called by chemists cerine is really cerotic acid, and that mycerine is a compound of palmitic acid and melissine. The lecturer here illustrated and explained the various adulterations of wax, giving the means of detecting them. The adulterations were common owing to its value.

Chinese wax is a compact substance, imported from China, and said to be secreted by an insect called *Coccus Pela sinensis*. This wax, which is harder and more brittle than beeswax, melts at 181, and has yielded in the hand of the above eminent chemist cerotic acid and cerotine, or oxide of cerotyle

(To be continued.)

On the Supposed Nature of Air prior to the Discovery of Oxygen.

By GEORGE F. RODWELL, F.C.S.

From the London Chemical News, No. 200.

Continued from page 200.

XII. *Rise of Scientific Societies.*—In the preceding paper we have considered the labors of the Accademia del Cimento in connexion with the subject under discussion. We have now to speak of two institutions which, unlike the Italian Academy, have endured to our time, and have year by year extended their influence on the progress of the Baconian philosophy, until they have become the very centres from which its greatest results emanate—the Royal Society and the Academie des Sciences.

A few years after the death of Bacon, some of the more ardent of

the followers of the "new philosophy" agreed to meet weekly at each other's rooms for the trial of experiments, and for the discussion of subjects connected with experimental science; when the number of members of this infant society had somewhat increased, the meetings were held at the "Bull's Head," in Cheapside, and subsequently at Gresham College, but the latter was converted into a garrison during the Commonwealth, and the meetings were discontinued till 1660, when they were resumed at the College. The Society now received large accessions to its numbers, a journal book was commenced, and rules were drawn up relative to the election of officers and the admission of fellows. On December 5, 1660, it was notified to the members, that Charles II. had received information of the establishment of the Society, and that he had approved of its design, and desired to promote its welfare. In 1662 a charter was granted to the Society, rendering it a corporate body, under the title of "the Royal Society for improving natural knowledge." "*Nullius in Verba*" was chosen as the motto of the Society, and it may fitly be taken as the motto of the Baconian philosophy.

We have previously mentioned that Baptista Porta called one of his scientific works "Natural Magic," to distinguish it from contemporary writings on similar subjects, in which unusual physical effects were attributed to supernatural causes; now it was for a like reason that the Royal Society was defined as an institution "for improving *natural* knowledge." It was founded at a time when much of the superstition of the Middle Ages still prevailed, when it was no uncommon thing to burn those suspected of witchcraft, to cast horoscopes, to seek for hidden treasure with divining rods, to practise many of the old Chaldæan mysteries. The Society was to ignore all this; it was to look to natural causes for the explanation of new or hitherto unexplained phenomena, and to prove the fallacy of those superstitions which Bacon had spoken of as "mere levities that have little in them of certainty and solidity, and may be plainly confuted by physical reasons."* The influence of the Society in this direction was considerable, for we find a manifest lessening of superstition soon after its establishment.

Among the early fellows of the Society were Ward, Wallis, Sir Robert Moray, Bishop Wilkins, and Robert Boyle; the latter labored most indefatigably for the good of the Society; indeed, it may be considered as in a great measure due to his influence, that it obtained a permanent footing. At the early meetings of the Society, the subjects discussed related chiefly to the Copernican theory, the spots of the sun, the Torricellian experiment, and the improvement of telescopes; experiments were made to determine the length of time that a candle continued to burn in a cubic foot of (*a*) common air, (*b*) rarefied air, and (*c*) condensed air; thin glass bubbles filled with air at the ordinary pressure were caused to swim in condensed air, and experiments were made on the increase of weight of some metals during calcination. It could not, however, be expected that the super-

* "Advancement of Learning," book 3, chap. 4.

stitious element so prevalent at this period, would be entirely excluded from the discussions of the Society, especially when it numbered among its fellows such men as Sir Kenelm Digby and Sir Gilbert Talbot; nor was it at once excluded. Thus on June 26, 1661, we read that "Dr. Ent, Dr. Clarke, Dr. Goddard, and Dr. Whistler, were appointed curators of the proposition made by Sir G. Talbot to torment a man presently with the sympatheticall powder." July 31: Mr. Croune exhibited before the Society a jar full of the powder of the bodies of vipers, and another full of the powder of the hearts and livers of vipers. On September 4, Sir Kenelm Digby read an account of "a petrified city and its inhabitants." Even the divining rods were thought worthy of examination by these early philosophers. July 10, we read: "The fresh hazell sticks were produced, wherewith the divining experiment was tried, and found faulty."

At this period but little was known of foreign countries, and travelers were wont to grossly exaggerate the wonders they had seen; and more than this, often to state the most glaring impossibilities—for instance, that diamonds grew in the mines in which they were found; that there existed a river of pure balsam; that in certain countries the natives whistled so loud as to be heard at a distance of five miles, and such like absurdities; we remember to have seen in the "Mundus Subterraneus" of Athanasius Kircher (a man who had traveled much) a detailed account, accompanied by an engraving, of an encounter with a dragon. At an early period of its existence, the Royal Society sent a number of questions to residents in foreign countries, with a view to ascertaining to what extent the assertions of travelers might be relied upon, and further for the purposes of scientific inquiry. In 1661 a number of questions were sent to a resident in Teneriffe; they were proposed by Lord Brouncker and Robert Boyle, and many of them were obviously for the purpose of ascertaining the difference between the air on the summit of a lofty mountain and that at its base. The recipient of the letter was desired, among other things, to try the Torricellian experiment at the top and bottom of the mountain, and to note the exact difference in the height of the mercury column; to carry up partially inflated bladders, and to observe to what extent they altered in bulk at various elevations; to weigh a bottle of air at the top and bottom of the mountain; to observe whether birds loaded in such a way that they can just fly at the bottom of the mountain, are able to fly at its summit; to ascertain if there is any moisture in the air at the summit of the mountain, and if a siphon will act there readily.

The first number of the Philosophical *Transactions* was published on March 1, 1665, and from that date to the present, the publication has been continued uninterruptedly. The early volumes contain a very miscellaneous collection of subject-matter; scientific articles were by no means alone admitted—sometimes we find two of the most diverse subjects treated of in the same communication; thus in the number of December, 1667, there is an "Extract of a letter written by Mr. Sam. Colepress to the Publisher, containing an account of some

Magnetical Experiments; and also of an excellent liquor made of Cyder-apples and Mulberries." Astronomical papers occur rather frequently; medical papers less so; articles on pure physics are by no means common; the reviews of recently published books are of great interest and of frequent occurrence. We will briefly consider the various papers of importance connected with our subject which occur in the Philosophical *Transactions*.

1665. No paper relative to the air.

1666. Under the title of "*A New Statical Baroscope*," Boyle describes an apparatus for showing changes in the weight of the air, which he considers preferable in many respects to a mercurial barometer. At one extremity of the beam of a balance capable of turning with $\frac{1}{30}$th of a grain, he suspended a sealed glass sphere full of air, about the size of a large orange; it was exactly counterpoised by a lead weight placed on the opposite extremity of the beam; minute movements of the beam were made apparent by an index which pointed to an accurately divided arc; the position of the sphere of course varied with changes in the density of the air, an alteration in which, represented by a rise or fall of one-eighth of an inch in the mercurial barometer, was clearly indicated by the statical baroscope.—Dr. Beal gives a number of barometrical observations, and states that he never found the mercury column higher than $30\frac{1}{4}$ inches, nor the extreme change to exceed $2\frac{3}{8}$ths inch. Dr. Wallis, during a great number of observations, did not observe the mercury higher than 30 inches, or lower than 28; he found it rise in foggy and sunshiny weather, and fall in wet and windy weather. Boyle, in giving directions as to how barometers should be observed, urges the necessity of ascertaining the exact elevation above the level of the sea of two localities, in which separate barometical observations intended for after comparison are being made—a point of great importance, which up to that time had been overlooked. In detailing the "General Heads for the Natural History of a Country," Boyle writes as follows: "Concerning the air, may be observed its temperature, as to the first four qualities and the measures of them; its weight, clearness, refractive power; its subtilty or grossness; its abounding with or wanting salts; its variations according to the season of the year, and the times of the day; what durations the several kinds of weather usually have, what meteors it mostly produces, and in what order they are generated, &c."

1667. Some experiments are mentioned by Dr. Beal relative to the growing of seeds in vacuo. Lettuce seed was planted in earth, part of which was placed in the open air, and part in vacuo; in eight days the seed which was planted in the open air had produced plants one and a half inch high, while that in vacuo had not sprouted; on admitting air to the receiver, the included seed produced plants from two to three inches high in a week's time. In a short notice of "*An Experiment of Sigr. Fracassati upon Blood Grown Cold*," we find mention of an important fact hitherto unobserved, or at least unrecorded. The dark color of venous blood had for a long period been believed to be due to an admixture of the "melancholy humor," (one of the four

supposed constituents of blood.) Fracassati observed, however, that when dark colored blood was exposed to the air, its upper layer became bright red, while the blood beneath remained dark-colored; from whence he infers that the dark color of blood is not due to the "melancholy humor," but to the want of an admixture of air, since the presence of air at once converts it into red blood.

1668. In the *Transactions* for this year we have an interesting paper by Boyle, entitled "*New experiments concerning the relation between Light and Air in shining wood and fish*," in which we find, among others, the following experiments: A piece of luminous rotten wood was placed under the air pump receiver; on exhausting it ceased to emit light, but when air was admitted the luminosity returned. In order to see if the light could be perfectly distinguished like that of a red-hot coal placed in a vacuum, pieces of luminous wood and fish were left in an exhausted receiver for from twenty-four to forty-eight hours. On admitting air the bodies immediately regained their luminosity. A piece of luminous wood was placed in a vessel into which air was compressed, but the wood did not shine brighter than before. A piece of luminous fish was placed in a bottle of water, which was included within a receiver, and the air exhausted, but no effect was produced. In order to ascertain whether "the cold fire" of shining wood could be maintained by a very small quantity of air, a piece of wood was hermetically sealed in a glass tube; it retained its luminosity perfectly for a length of time.

1669. No paper relative to the air.

1670. Boyle contributes an interesting paper entitled "*New pneumatical experiments about respiration.*" We have previously mentioned Boyle's experiments on respiration which he described in the first "Physico-mechanical experiments touching the air." In this paper we have a continuation and enlargement of his former experiments; those here described were principally made in 1662 and 1663. As ducks are able to remain for an appreciable time under water, Boyle conceived that they would form good subjects for experiment. Accordingly he enclosed one in the air-pump receiver and exhausted, whereupon the duck was brought to the point of death in a few minutes. A viper was alive at the end of two and a half hours, during which it had been kept in an exhausted receiver; a second was enclosed in a very small receiver, which was well exhausted; at the end of an hour and a half it was to all appearances dead, but on admitting air twenty-three hours afterwards, it proved to be alive. A large frog placed in a receiver was observed to swell out considerably when exhaustion was commenced; in a short time it appeared to be dead; at the end of three hours air was admitted to the receiver, and the inflated frog immediately shrank up to a very small size, still to all appearance dead; nevertheless, on being placed over night on grass in the open air, it was found to be alive and well the next morning. In order to ascertain whether animals "that had been lately accustomed to live without any or without a full respiration would not be more difficultly or slowly killed by the want of air, than others which had

been used to a free respiration," Boyle placed a kitten (born the previous day) in a small receiver and exhausted. At the end of six minutes it appeared perfectly dead, but on removal to the open air it recovered after a while; a second kitten which was left in vacuo for seven minutes did not recover when air was admitted. An oyster was kept in vacuo for twenty-four hours, and remained alive; a crawfish also lived in vacuo; a leech which was kept in an exhausted receiver was found to be alive and well at the end of five days. The heart of an eel just taken out was placed on a tin plate in an exhausted receiver; it continued to beat for an hour. A gudgeon remained alive for some time in vacuo. From the numberless bubbles of air which ascend from water placed in vacuo, Boyle puts it as a query "whether in common water there may not be concealed air enough to be of use to such cold animals as fishes; and whether it may be separable from the water that strains through their gills." In order to see if the volume of air is altered by animals breathing in it until it is incapable of supporting life, birds and mice were placed in tubes together with a mercury gauge, the tubes were then hermetically sealed, and put aside until the animals and birds were suffocated; the gauge indicated no change in the volume of air within the tubes. As it would be of service in our comprehension of the minuteness of a particle of air, if it could be proved that very minute insects breathe, Boyle placed a number of mites in a small receiver and exhausted; on examining them with a lens, they were observed in a short time to become perfectly motionless, and to continue so, but on the admission of the air they manifested considerable liveliness, whence he considers that it may be taken as proved that they breathe.

1671. The only paper of interest in connexion with our subject in this year's *Transactions* is a short one on "*The Compression of Air by Water*," in which the following experiment is detailed: A glass bottle of a quart capacity was fitted with a valve opening inwards; it was sunk in the sea, mouth downwards, to a depth of thirty-three feet; on drawing it up, it was found to be half full of water, proving that the weight of a column of water of thirty-three feet high had compressed the air in the bottle to half its volume, as might have been predicted from the previous experiments of Boyle and Hooke on the compression of air by a column of mercury.

1672. When a tube five or six feet long, closed at one end, is filled with mercury perfectly free from air, and then inverted into mercury, after the manner of making the Torricellian experiment, the mercury in the tube will frequently be found to remain suspended at a much greater elevation than that at which the pressure of the atmosphere would cause it to remain; but if the tube be shaken, or if a slight blow be given to it, the column at once falls to its usual height of 30 inches above the stagnant mercury. In order to account for this, Huygens proposed a most unphilosophical theory, (contained in a letter to the *Journal des Savans*, and reprinted in this year's *Phil. Trans.*,) which affirmed that, in addition to the pressure of the air, there is a second pressure of a more subtle matter than air, which is able to

penetrate glass, water, and mercury, and that it is due to this additional pressure that the mercury column under the above circumstances remains suspended above 29 inches. Although this hypothetical matter could penetrate glass, Huygens conceived that so long as the mercury was absolutely in contact with the end of the glass tube, so that there was no free space in the tube, it could not be readily pressed upon, but on shaking or jarring the tube, the mercury was separated from its close contact therewith, and the subtle matter immediately rushed in and caused the descent of the mercury. He conceived further that the presence of this additional pressure was proved by two experiments: the one, that a siphon will act *in vacuo;* the other, that two perfectly plane plates placed in contact will not separate *in vacuo* any more than in air, although a weight may be attached to them.

The Académie des Sciences was founded 1666, mainly by the exertions of Colbert, Carcavy, Auzout, Huygens, and Roberval. During the century it published ten volumes of proceedings, known as the "Anciens Memoires de l'Académie." In 1699 the Academy underwent an entire reorganization, and from that time to the present the memoirs have appeared more frequently.

There are only two papers of interest in connexion with our subject which appeared before 1673, (to which date we have taken our notices of the *Philosophical Transactions.*) The first is "On the Augmentation of Weight of Certain Matters during Calcination." In this the author, M. du Clos, gives the following explanation of the cause of the increase of weight observed. He conceives, "Que l'air qui coule incessamment vers les endroits, où il y a du feu, laisse surces matieres embrasées pleine de souffres terrestre, des particules sulphurées plus volatiles, qui s'unissent avec eux, s'y fixent, et forment ces filamens dont nouse avons parlé, qui sont apparemment toute augmentation du poids." The other paper details some vacuum experiments, almost all of which had been previously made. No mention is made of Boyle's air pump, and Otto Guericke's form of the instrument was apparently employed. In order to ascertain whether heat passed as readily through a vacuous space as through air, some butter was placed in a receiver, and a hot iron held as near to it as practicable outside the receiver. The butter did not melt so readily when the receiver was exhausted as when it was full of air, probably, according to the author, (whose name is not mentioned,) because air in virtue of the grossness (grossièreté) which it possesses, is more capable of conveying heat from the hot side of the receiver to the butter than the very thin and subtle matter which remains in the receiver after the air has been pumped out.

(To be Continued.)

On the Decay of Materials in Tropical Climates, and the Methods employed for arresting and preventing it. By G. O. Mann.

From the Civil Engineer and Architect's Journal, December, 1864.

The facts and experience recorded in this paper had reference particularly to the empire of Brazil, the author being the resident engineer and

locomotive superintendent of the Recife and San Francisco Railway Company. It was stated that the temperature varied less probably than in any other quarter of the globe; but the seasons, which it was believed influenced the decay of materials to a greater extent than the temperature were not so regular. Thus, the rainfall ranged from 60 inches to 120 inches per annum, and this did not occur at any particular period, though a certain peculiarity in the climate, excessive heat combined with much moisture, was noticeable more or less throughout the year.

It had been found on the Pernambuco railway, that the half-round intermediate sleepers, of timber from the north of Europe, creosoted, were in a better state of preservation than the square sawn joint sleepers of the same material; still, after seven years' trial, it was evident that creosote, when properly applied to suitable descriptions of timber, would prevent decay. In white-sand ballast, since the opening of the first section of the line in 1858, the half-round sleepers had not suffered a depreciation of more than one per cent., while the square sawn sleepers had experienced a depreciation of not less than fifty per cent. On the other sections of the line, sleepers of native timber were employed with unsatisfactory results; this was due, it was asserted, to the timber having been cut at unfavorable seasons, and to the sleepers having been laid in a green state, owing to the rapid progress of the works not allowing time for them to become dry. The author, after nearly seven years' experience, was confident, however, that properly selected timber of the country would be found more durable than any description of wooden sleeper yet imported. It was advisable, in order to prevent decay, to cut the timber during the dry season, to select large and full-grown trees, to remove the whole of the bark and sapwood, leaving the heart of the timber only, and not to expose the sleepers in the sun when fresh cut, but to stack them in open piles under cover, through and about which the air could freely circulate for a few months. The cost of such sleepers delivered at the stations on the Pernambuco railway was at present 2*s.* 7*d.* each, the scantling being 10 inches by 5 inches by 9 feet. Imported creosoted sleepers had invariably cost double that amount.

Respecting timber in general, it was remarked that good timber for building purposes abounded in Brazil, in the greatest variety. Many kinds were impervious to the white ant, which insect generally selected the more porous descriptions, and particularly those in contact with the earth. In dry places, and with a free circulation of air, the white ant did not, in preference, select timber thus situated for its ravages; and it was found that the roofs of buildings, of good and well seasoned native timber, resisted for an indefinite period, both the climate and the white ant. Latterly it had been the practice to "pay" over, with coal tar, the ends of all timber built into the gables of buildings, or in any other position in which it was buried, or excluded from the air, and so far apparantly with beneficial results. Two specimens were exhibited of the piles of the old Recife wooden bridge, which had been constructed in 1614, in proof of the durability of the native timber; and it was asserted that, with proper precautions, no foreign

timber would be found able to compete in the tropics with that of native growth.

The only examples of iron bridges in the province of Pernambuco, except that of St. Isabel, completed in 1863, were those belonging to the railway. The result of a careful examination of four of these structures, after they had been erected six years, was to show that the cast iron pipe piles, forming the piers, were likely to remain good for a considerable period; and that the upper structures of wrought iron would also last well with ordinary attention. The only parts apparently affected were the wrought iron bracings, and the bolts and nuts below high-water mark. With regard to the preservation of iron bridges, and of iron work in general, for the tropics, care should be taken to insure the iron being perfectly dry before the paint or any other composition was laid on. Coal tar had been found to afford a most efficient protection. It was advisable that all small pieces should, before being shipped, be heated to a low temperature, and then brushed with, and dipped in, tar; the larger parts should be well cleansed, and the tar laid on while hot. Where tar was objectionable, linseed oil might be applied in the same way, and over this there should be a thin coating of zinc paint.

With regard to building materials, stone, wherever it could be obtained at a reasonable price, should be preferred for the abutments and piers of bridges. Stone imported from Portugal, for facing the churches, and in a few old Dutch works of the seventeenth century, had been found to be very durable. Great caution was necessary in the selection of bricks, as those made near the sea-board, with brackish water, were very susceptible to the weather, and mouldered away rapidly when exposed. As it was all but impossible to obtain thoroughly well-burnt bricks in large quantities, all brickwork near to the sea-coast required to be protected with plaster from the first, and in the interior this was ultimately necessary, or else a thick coating of lime whitewash might be given from time to time. Tiles made of similar, though where obtainable of better, clay, when well burnt, were scarcely affected by the weather, either on the sea-board or in the interior. Rafters were selected from young trees, and if of the proper quality of timber, had considerable duration. Laths were in nearly all cases made from the sap wood of "imberiba," perhaps the hardest and most durable description of timber in Brazil.

The permanent way keys, used for renewals since the opening of the Pernambuco railway in 1858, had been cut from native timber, of a remarkably close nature, which did not shrink, as the imported keys were found to do. The rails oxidized when left near to the sea-coast, so that it was desirable to remove them to the places where they were to be used as soon as possible. The motion of the trains appeared to prevent rust from forming on the rails, but owing to the high temperature they were always at during the day, and to the constant passage of the trains, there was tendency in them to become flattened. About 10 miles of the line had been laid with Greaves' "pot" sleepers, as to the durability of which in the tropics there could be no question,

but they were found to make a rigid road, even in fine sand ballast. This portion of the line had been improved, by introducing fish plates, and suspending the joints. The railway carriages were made with a strong wrought iron under-frame; the body and the inside lining were of teak; and the outside panels were of papier maché. These carriages were in excellent preservation, after six years' work and exposure to the sun and rain.

In the appendix a list was given of those Brazilian timbers now being used for sleepers on the Pernambuco railway, and of such as were suitable for general purposes in permanent structures, as well as a table of the specific gravities of the kinds adapted for ship building.

On the Decay of Materials in Tropical Climates.

By WILLIAM J. W. HEATH.

From the London Civil Engineer and Architect's Journal, January, 1865.

During a residence in Ceylon, extending over a period of seven years, while engaged on the railway, Mr. Heath's attention had been directed to those materials which were most used in the construction of permanent buildings. The habitations of the lower class of natives were formed of a rude framework of stout bamboos, the sides and roofs consisting of reeds, closed in with the interwoven leaves of the cocoanut palm, the latter being washed over with the slimy juice of a native fruit, which, when dry, resembled copal varnish. In the huts built of "wattle and dab," the framework was made of roughly squared jungle trees, the space between being filled, and both the inside and the outside of the hut being covered with clay and sand well kneaded, afterwards plastered over with earth thrown up by the white ants, mixed with a powerful binding substance produced by the ants. Superior houses were built of "cabook," a soft kind of rock, found at a few feet below the surface. This material had the appearance of a coarse sponge, the interstices being filled with clay. Before being used the blocks should be exposed to the rain, to allow some of the clay to be washed out. Cabook required to be protected from the weather, but if covered with a thin coating of lime plaster, it would last for years. Hard kinds of stone were not much used owing to the expense of working them; and rubble masonry was not approved, as there was difficulty in obtaining even bed sand good bond. Bricks as a rule were so badly burnt, and the clay was so badly pugged, that brickwork in exposed situations and unprotected would perish very rapidly. It was advisable that it should in all cases be well plastered with lime mortar. Two or three coats of boiled linseed oil would preserve brickwork without hiding it, but the expense prevented its general use. Coal tar was an excellent preservative, but on account of its unsightly appearance it could not be often employed. Lime was generally made by calcining white coral. When taken from the kiln it was in a fine white powder, fit for immediate use, after being mixed with twice its

own bulk of sand and water. It set so rapidly that, in the Public Works Department it was the practice to keep the lime under water for two days before using it. This had the effect of making it longer in setting, but it was more easily worked, and eventually made better work, equal, in fact, to the best blue lias lime. Well seasoned timber, with free ventilation, would endure for many years, if the white ants were kept away, without any precautions being taken to preserve it. In exposed situations, and where subject to the attacks of the white ant, Stockholm tar was the best preservative; while creosoted timber was free from their ravages. In sea water, and even in fresh water lakes and canals, timber was speedily attacked by worms, notwithstanding that it might be painted, oiled, or tarred.

Iron exposed to the influence of varying weather speedily oxidized, but oil, applied hot, was a good preventive. Coal tar was, however, the best covering applied either cold or hot, or before or after oxidation had commenced. Ordinary galvanized sheet iron did not last many years, unless protected with good red lead paint frequently renewed; but zinc would last for many years with little or no decay.

In the course of the discussion it was stated that on the Great Indian Peninsula Railway, Baltic sleepers both creosoted and kyanized, and native jungle wood sleepers had been used; but after thirteen years' experience, those which had failed were being replaced by teak and iron sleepers. The native woods were so hard and close grained that they could not be impregnated with any preservative substance. The keys were a source of great trouble in warm and variable climates. Those of wood had not been found efficient in India, and endeavors were now being made to devise a substitute. Iron work of all kinds should be thoroughly cleansed, dried by heat, and then dipped in hot linseed oil before being exported from this country.

It was contended that it was impossible to predicate what timber would sustain, for while yellow pine had been known to last sound as railway sleepers for twenty-five years, in other cases it had decayed in five or six years. This frequently happened also with hard tropical woods, without there being any apparently assignable cause for this difference in the rate of decay. Hence, in the tropics, iron was nearly the only material that could be employed especially for sleepers with anything like certainty as to the results. No doubt iron made a rigid permanent way unsuitable for the high speeds common in this country, although possibly this might be partially obviated by a more perfect manner of securing the rails on the sleepers; but in the tropical climates the use of iron was almost a necessity, and there a speed of from 25 to 30 miles per hour was a maximum. Greaves' cast iron bowl sleepers had been laid for eighteen years on the Egyptian railway, and made a good and substantial road. The objection that they were liable to break, particularly along the centre line, might be met by making them stronger; and it was remarked that on the Dom Pedro Segundo Railway, Rio Janeiro, the bowl sleepers had been in use for eleven years, and only one sleeper per mile had required to be renewed.

On the East Indian line, of more than 100 miles in length, the sleepers were principally of sâl timber, but there were others of creosoted fir and of iron. Although there were many different kinds of suitable native woods, there was difficulty in obtaining large quantities of any other than sâl, which, when cut out of large timber and well seasoned, was very durable. Recently in opening a part of the line near Calcutta, sâl sleepers had been found in a good state of preservation after having been laid twelve years. In other parts of the line, creosoted sleepers were in a serviceable condition after being in use ten years. Teak was perhaps the best of all Indian woods, but the cost precluded its use for sleepers, as it would amount to 15*s*. per sleeper. Flat iron sleepers had been unsuccessful, but cast iron bowl sleepers seemed to promise better results, although at present they had not been sufficiently long in use to enable a definite opinion to be pronounced. The breakage so far had been serious, amounting to about 20 per cent., but this might be obviated in future by making them stronger, as had been suggested. The use of iron was desirable on account of the difficulty of obtaining large supplies of timber sleepers, and the uncertainty as to their quality.

Although the decay of materials in Ceylon was unquestionably influenced by the alternating effects of heat and moisture, yet it was believed to be principally due to the use of inferior materials. In the upper districts of India, there were brick and stone buildings of great antiquity, in fact anterior to historic periods. Sâl timber was hard, durable, and abundant in the central forests, and along the base of the Himalayas, and had been generally employed by the Public Works Department; but owing to the great demand of late years, it was now hardly possible to obtain it well seasoned. Teak was also becoming scarce; that which grew in the province of Burmah was of large size and very useful for shipbuilding; while when cultivated in a drier range and upon rocky ground it was as hard as ebony or iron wood, though of small scantling and of crooked form.

It was noticed as remarkable that the observations in one paper were repeated in the other, and that the means of preservation which had been suggested as applicable in Brazil, were likewise recommended for Ceylon. There were, however, some points of difference—especially as to the use of galvanized iron. The author of the first communication, speaking apparently from opinion rather than from experience, advised its use, while the author of the second, on the contrary, thought that galvanizing alone, without painting or tarring, was not adequate to protect iron in such climates. As corroborative of the remark, that the loss of weight in iron from oxidation was less in Ceylon than in England, in an equal period of time, it was mentioned that out of a quantity of rails, which had been manufactured at the same time and at the same place, some were lying for many months unused in Ceylon, and others in South Wales, when the loss of weight by rust was found to be largely in excess at the latter place. Where there was great heat, combined with excessive moisture, it was imagined that the effect upon materials, particularly timber, could not be otherwise

than serious. While, in the first instance, it might be prudent to import timber artificially prepared, owing to the absence of available data as to the character of the native materials, yet it was believed, as the qualities of the different kinds of native woods became better known, as well as the proper time to fell them, and to prepare them by shed-drying or otherwise, and as a more ready access was obtained to the forests, native woods might ultimately be used with advantage and economy. In fact, a specimen of native Brazilian wood had been exhibited, which had endured for two hundred and fifty years. The alleged excessive wear of the rails and tires in Pernambuco must be explained upon other grounds than the heat. Perhaps the fact that the rails were not "fished" until after a portion of the line had been opened for traffic, that there were considerable curves on the line, and that the road was not laid in the perfect manner which was possible in this country, added to the great atmospheric alternations, might be sufficient to account for it.

It was remarked that in using unprepared wood, no doubt it was desirable to select that part which is hard, as the pores being filled with ligneous matter, such timber did not so freely absorb moisture. But for creosoting purposes the reverse was the case, for it was impossible to make heart-wood absorb 10 lbs. of oil per cubic foot, as was sometimes required. The great value of creosoting was that it enabled young wood to be used, as then, the pores being filled with a bituminous asphaltic mastic, the wood so treated was perfectly water proof, and harder than heart-wood. The reason why the half round sleepers on the Pernambuco line were more durable than those of square form, was believed to be due to all the young wood being retained in the former. Recent experiments in the harbor of Ostend showed that wood prepared with corrosive sublimate, or with sulphate of zinc or copper, was only partially protected against the worm, but when creosoted the worm would not touch it. It was advisable that piles in sea water should not be squared, but used round, with as much young wood as possible.

Respecting the ravages of the white ant, there were many old structures in Brazil not so affected; and as regarded railway sleepers, the frequent shaking and vibration would, it was considered, render them tolerably safe. In that country, porous and open-grained timber seemed most subject to these attacks; but in Australia the hardest kinds were first attacked. This was especially the case with iron bark timber, the density of which was so great as to cause it to sink in water, and in tenacity and resistance to strain it approached rough cast iron. White ants were effectually destroyed by oil of creosote, and anything of a bitter taste injected into the fibre, or even a small quantity of turpentine, would prevent their attacks. In some parts of India white ants were very destructive, and 10 per cent. of some stacks of sleepers had been decayed at the heart, in from six to eight months. The black ants of the West Indies were also more destructive in hard than in soft wood. Some descriptions of wood there were, neither affected by the teredo navalis, nor by the black ant, and when used for piles had never been known to decay.

With regard to stone it had been found that the application of linseed oil not only acted as a preservative, but it rendered soft stone in the course of a short time very hard. In Jamaica, the bricks were well made and of good materials; and some buildings there had stood from time immemorial without exhibiting any signs of decay. Mortar, both there and at the Cape, was made of shell lime, and even when mixed with sea sand it was hard and durable. In India, the addition to the lime of 5 per cent. of jaggery, a coarse native sugar, caused the mortar to set well and to be very durable. At the Cape the bricks were not good, and owing to the exudation of phosphate of soda after the work was finished, it was advisable to plaster all brickwork. In India the telegraph posts were, to a large extent, of stone obtained from Agra, and the rapid decay of timber when used for that purpose had greatly retarded telegraphic extension in that country. The difficulty was now being met by making the lower parts of the posts of iron, into which wooden posts were inserted.

Respecting the statements that the only examples of iron bridges in the province of Pernambuco were those belonging to the railway, and that of St. Isabel, completed in 1863, it was remarked that, about twenty years ago, a French engineer, M. Vauthier, when engineer-in-chief to the Province, designed and erected a suspension bridge on one of the main roads, about nine miles from the city, across the river Capibaribe, at the village of Caxangà. The roadway, which was 100 feet long by 20 feet wide, was suspended from a pair of iron wire ropes on each side of the bridge by vertical rods of wrought iron, the attachment of the rods to the ropes being by means of strong wrought iron plates, embracing both ropes. Each rope was in four separate pieces, and consisted of a mass of wire simply laid together and bound at intervals. The rocking standards were of cast iron in three pieces, and the platform was of wood. All the work was executed in the country, including the casting of the standards, but the wire was purchased in England. The ropes as well as the cast and wrought iron work were still sound. The cost had amounted to between £5000 and £6000.

Electricity.—Measurement of Inductive Resistances.

From the London Mechanics' Magazine, February, 1865.

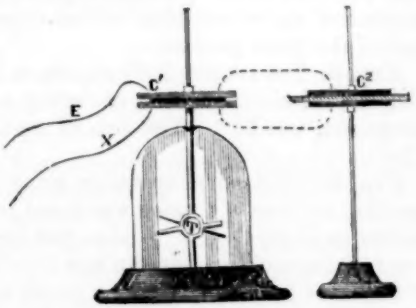
In a recent article, we noticed a system of measuring inductive resistances which will probably be found applicable with advantage whenever considerable lengths of manufactured cable are to be tested. We have now to describe a method which may be found particularly useful in testing specimen lengths of covered wire, even of a few inches, or samples taken from the bulk of materials considered to be adapted for the insulation of submarine wires; and which may consequently be of advantage to the manufacturer, and those generally who are engaged in perfecting the *materiel* of submarine telegraphy. The method in question is, if the results obtained be carefully worked out, susceptible of very great accuracy in what may be termed the quantitative

measurement of inductive resistance, but its practical value mainly resides in the fact that it affords a ready means of roughly determining the relative merits of samples of insulating materials in regard to their specific inductive resistance, and also, when necessary, in regard to their resistance to the passage of electricity. Such a method has, in fact, long been required by those engaged in the manufacture of submarine cables, or in investigations relative to their construction.

Since the specific inductive resistance of various materials would be proportionate to the quantity of electricity communicated from a given source to a number of wires, of equal length and diameter, respectively covered to an equal thickness with the materials in question, (the outer surface of the insulating materials being coated with tin-foil, or other conductive substance, and in connexion with earth,) it might be assumed that this property would be determined with sufficient accuracy for practical purposes by merely bringing each of the coated wires, successively, in contact with a Peltier or other electrometer charged to a given number of degrees, say 60 deg., and observing the diminution in the deflection produced in each case. Such, indeed, would be the fact if the conductive resistance of the materials might be considered as infinitely great; but, practically, a charge of the tension requisite to give comparable readings upon the electrometer (a tension, perhaps, equal to that of a battery of several thousands of cells,) would instantly, on contact being made with the wire, be almost wholly discharged from the instrument, the electricity flashing to earth through the substance of insulating material.

It is necessary, therefore, in order to render practicable so simple a mode of testing, that the tension necessary to furnish the indications should be—to use an almost absolete but expressive electrical term—*dissimulated* in great measure, whilst contact is made between the electrometer and the coated wire. This observation will probably suffice to render perfectly intelligible the *rationale* of the method now to be described. To the electrometer is fitted a condenser of an inductive resistance proportionate to the resistances to be measured—*i.e.*, a metal disk is screwed upon the upright stem of the instrument, and upon this disk is placed a second one, furnished with an insulating handle; the size of the disks and distance between them (maintained by means of a few drops of sealing wax upon either plate) being regulated according to the length of the sample insulated wires to be tested. If, now, the upper plate of the condenser be brought into contact with a wire connected to earth, whilst at the same time the lower plate is brought into contact with one pole of a properly insulated battery of 80 or 100 cells, (the other pole of which should be to earth,) the apparatus will receive an electrical charge of considerable *quantity*, but of a tension sufficient only to produce a very slight deflection of the electrometer needle. When, however, we remove the upper plate of the condenser by means of its insulating handle, the needle will be very strongly deflected, the original deflection of (say) 2 or 3° becoming 30 or 40°, according to the size of the condenser and the distance between the plates.

If, upon charging the electrometer by means of the condenser several times in succession, we obtain a constant deflection when the upper plate of the condenser is removed, we may then be tolerably certain that the whole of the apparatus is in proper condition, and we may in that case proceed to the testing of samples of insulating materials. These samples may either be in the form of similar short lengths of wire coated to the same thickness in each case with the respective materials, or in the more convenient form of small portions of the material in bulk, rolled or cast into sheets of *equal thickness*. In the latter case the sheets, which need not be cut to the same size, are to be inserted between the two plates of a second small condenser, one of which plates, insulated from earth, represents the wire in a short length of cable; whilst the other, connected to earth, represents the conducting substance in contact with the external surface of the insulating material upon this wire.



It is evident that if, after having charged from the battery the lower plate of the condenser attached to the electrometer, and whilst the upper plate is still connected to earth, we bring the former into contact with the wire, or disk, insulated from earth by means of one of our samples of insulating material, a certain quantity of electricity will be abstracted from this charged plate. This quantity, under the conditions in which the experiment is performed, will be proportionate to the specific inductive capacity of the insulating material in question, which will, therefore, be approximatively indicated by the greater or less deflection of the galvanometer needle when the upper plate of the condenser is removed. Such is the simple principle upon which dependable quantitative results may directly be obtained upon this system of testing. To exemplify the process, we may instance some tests applied to four specimens of insulating materials, viz: of gutta percha, india rubber, Macintosh's compound of india rubber and paraffin, and pure paraffin. The deflection of the galvanometer needle upon charging the condenser was about 3°. When the upper plate of the condenser was removed, the deflection became 31·5°. This result was obtained five times consecutively.

Exp. 1. The condenser was again charged from the battery, and, before breaking the connexion of the upper plate with earth, the lower plate was brought into contact with the insulated plate of a second condenser, which, as previously described, enclosed a portion of a sheet of *gutta percha*, of the same thickness as the sheets of other materials to be tested. Upon raising the upper plate of the electrometer condenser, the indication obtained was 15°, *i. e.*, the loss of tension was in this case 16·5°.

Exp. 2. The electrometer condenser having been completely discharged, and subsequently again charged from the battery, the lower plate was brought into contact with the insulated plate of the second condenser, forming a Leyden arrangement with a sheet of para rubber; the upper plate of the electrometer condenser, and one plate of the second condenser being maintained in connexion with earth. Upon raising the upper plate of the electrometer condenser, the indication obtained was 19°, and the loss of tension was consequently in this case only 12·5°. As the tension varies directly as the quantity of electricity accumulated under the same conditions, it is evident that the quantity of electricity abstracted from the condenser was in this case less than in the previous experiment, and that the inductive resistance of the india rubber was consequently considerably higher than that of the gutta percha.

Exp. 3. The tension indicated upon the electrometer after contact with the second condenser, enclosing a sheet of Macintosh's paraffin compound, was 20°. The loss of tension was therefore in this case 11·5°.

Exp. 4. The same operation being repeated with a sheet of pure paraffin, the loss of tension was found to be only 8°; the electrometer indication being 23·5°. It thus was rendered evident that the inductive resistance of the paraffin was very considerably higher than that of the other materials tested, a result which, without any more accurate expression of the comparative resistances, was in itself of considerable practical importance.

In testing as above, the experimenter might, without liability to serious error in regard to the result in view, assume empirically: First, that the indications of the Peltier electroscope give the true measurement of the electrical tensions, and consequently of the quantity of electricity accumulated at any given time as a charge upon the instrument; and, second, that the specific inductive *capacities* of the samples of insulating material tested are proportionate to the loss of tension that occurs in each case after contact has been made between the two condensers as described. Upon this assumption, the specific inductive capacities would bear the following proportions to each other: Gutta percha = 16·5, india rubber = 12·5, india rubber and paraffin compound = 11·5, pure paraffin = 8, and the specific inductive *resistances* would be as these numbers inversely.

The theory, however, of the distribution and redistribution of a given quantity of electricity in two or more branches of an inductive circuit, when an alteration in the conditions of this circuit takes place after the source has been withdrawn,* is now very generally understood; and the electrician will have but little difficulty in obtaining an accurate quantitative expression of the specific inductive resistances of samples of insulating materials tested upon the above system, provided he can assume that the electrometrical indications (obtained by means of a Peltier instrument graduated to verified battery tensions, or of a Thomson's electrometer) are sufficiently near the truth. The electrical law ap-

* Vide F. C. Webb's "Electrical Accumulation and Conduction," chap. 5.

plicable to the case under consideration is stated by Mr. F. C. Webb, as follows: "The quantity generated at one pole of a source will divide itself on the surfaces which it charges in the inverse ratio to the inductive resistance separating those surfaces from the opposing surfaces, to which the other pole is connected." Thus, if we call Q the quantity of electricity accumulated upon the condenser No. 1 (that attached to the electrometer); Q' the quantity of electricity accumulated upon condenser No. 2 (that enclosing the sheet of insulating material); R = 1 the inductive resistance of condenser No. 1; and R' the inductive resistance of condenser No. 2, equal to the specific inductive resistance of the sample of insulating material tested:

$$\text{then, } Q' : Q :: R : R' \text{ and}$$

$$R' = \frac{Q\,R}{Q'};$$

$$\text{or, since } R = 1,\ R' = \frac{Q}{Q'}.$$

The theoretical deductions from the experiments above described, in which the specific inductive resistances of four different specimens of insulating materials were tested, would be as follows, assuming always the electrometrical indications to be sufficiently accurate: calling T and T' the tensions upon condenser No. 1 and condenser No. 2, respectively; upon charging condenser No. 1 from the battery, as previously described, and raising the upper plate,

$$T = 31{\cdot}5$$

$$Q = \frac{T}{R};$$

R being constant, Q = 31·5, and

$$R = \frac{T}{Q} = \frac{31{\cdot}5}{31{\cdot}5} = 1.$$

Exp. 1. Determination of inductive resistance of gutta percha. When the upper plate of condenser No. 1 is raised, after connecting condenser No 2 as a branch inductive circuit, T = 15; Q = 15; R = 1; the electrical conditions in condenser No. 2 would be, in like manner: T' = 15; Q' = 31·5—15 = 16·5; and $R' = \frac{15}{16{\cdot}5} = 0{\cdot}909$. (Applying the well known equation for branch circuits, inductive or conductive, viz: $R = \frac{r\,r'}{r + r'}$; the total resistance of the combined circuits is $R = \frac{1 \times 0{\cdot}909}{1 + 0{\cdot}909} = 0{\cdot}47616$; and the total $Q = \frac{15}{0{\cdot}47616} = 31{\cdot}5$, remaining, of course, unaltered.)

Exp. 2. Specific inductive resistance of india rubber. Condenser No. 1: T = 19; Q = 19; R = 1. Condenser No 2: T' = 19; Q' = 31·5—19 = 12·5; and $R' = \frac{19}{12{\cdot}5} = 1{\cdot}520$.

Exp. 3. Specific inductive resistance of compound of india rubber

and paraffin. Condenser No. 1: T = 20; Q = 20; R = 1. Condenser No. 2: T' = 20; Q' = 31·5—20 = 11·5; and $R' = \frac{20}{11·5} = 1·739$.

Exp. 4. Specific inductive resistance of pure paraffin. Condenser No. 1: T = 23·5; Q = 23·5; R = 1. Condenser No. 2: T' = 23·5; Q' = 31·5—23·5 = 8; and $R' = \frac{23·5}{8} = 2·9375$.

The specific inductive resistances of the four materials would therefore be as follows: Gutta percha 0·909, india rubber (pure para.) 1·520, compound of india rubber with paraffin (the specimen contained also some carbon in the form of lampblack) 1·739, pure paraffin 2·9375. It has been mentioned that the apparatus which is employed as above in the measurement of inductive resistances of specimens of insulating materials may also be applied to the determination of their conductive resistance. The mode in which the testing is in this case affected will be understood by the practical electrician, when it is stated that the pole of a battery is connected to one plate of what we have termed condenser No. 2, the other plate of this condenser being connected to the lower plate of the electrometer condenser, of which the upper plate is brought in contact with earth. At the end of a given time (a few minutes) the connexions are broken, and the last mentioned plate is removed. The electrometer indication will then indicate the amount of leakage which has taken place through the substance of the sample tested.

On a new Thermo-Element. By M. S. Marcus.

From the London Chemical News, No. 286.

The author has given the following accont of the properties and construction of his new thermo-element:

1. The electro-motive force of one of the new elements is $\frac{1}{25}$th of that of Bunsen's element, and its resistance is equal to 0·4 of a metre of normal wire.

2. Six such elements can decompose acidulated water.

3. A battery of 125 elements disengaged in a minute 25 cubic centimetres of detonating gas. The decomposition took place under unfavorable circumstances, for the internal resistance was far greater than that of the interposed voltameter.

4. A platinum wire half a millimetre in thickness introduced into the circuit of the same wire is melted.

5. Thirty elements produce an electro-magnet of 150 pounds lifting force.

6. The current is produced by heating one of the junctions of the elements and cooling the second by water of the ordinary temperatures.

To construct this battery it is necessary, on the one hand, to procure two electromotors suitable for a thermo-element, and, on the other, to have such an arrangement of the elements and of the means

for heating and cooling as will ensure as favorable a result as possible. The former constituted the physical, the latter the constructive part of the problem.

In solving the first part of the problem, it was the author's endeavor

a. To use such thermo-elements as are constructed of metals as far apart as possible in the thermo-electric series, and

b. Such as permit great differences of temperature without using ice, which is only practicable if the bars possess as high fusing points as possible.

c. The material of the bars must not be costly, and the bars themselves must be easily constructed.

d. The insulation used for the elements must be able to resist high temperatures, and must possess sufficient solidity and elasticity.

As neither the usual bismuth antimony couples, nor any combination of the other simple metals satisfy these conditions, M. Marcus availed himself of the circumstance that alloys in the thermo-electric pile do not stand between the metals of which they consist, and was thereby led to the following alloys, which completely satisfy the above requirements:

For the positive metal

10 parts of copper,
6 " zinc,
6 " nickel.

An addition of one part of cobalt increases the electro-motive force.

For the negative metal—

12 parts of antimony,
5 " zinc,
1 part of bismuth.

By repeated remelting the electro-motive force of the alloy is increased.

Or he used a combination of argentane (known as alpacca from the Triestinghofer Metal Manufactory) with the above negative metal; or an alloy of

65 parts of copper,
31 " zinc,

as positive metal, and an alloy of

12 parts of antimony,
5 " zinc,

as negative metal.

The bars are not soldered together, but bound by means of screws.

The positive metal melts at about 1200° C., the negative at about 600° C.

As in this element it is only the heating of the positive metal which influences the development of electricity, the arrangement has been made that only this is heated, while the negative metal receives heat by conduction. By this arrangement it is possible to apply temperatures of even 600°, and consequently to attain greater differences of temperature.

An interesting illustration of the conversion of heat into electricity is the fact that the water which is used for cooling the second

point of contact of the element becomes warm very slowly as long as the circuit is closed, but pretty rapidly if it is open.

The thermo-pile in question was constructed with a view to being used with a gas-flame. The individual elements consist of bars of unequal dimensions. The positive electrical bar is 7″ long, 7″ broad, and $\frac{1}{2}$‴ thick; the negative electrical bar is 6″ long, 7″ broad, and 6‴ thick. Thirty-two such elements were screwed together, so that all positive bars were upon one and all negative on the other side, and thus had the form of a grating. The battery consists of two such gratings, which are screwed together in a roof shape, and are strengthened by an iron bar. As an insulator between the iron bar and the elements, mica was used. Besides this, the elements, where they came into contact with the cooling water, were coated with soluble glass. An earthen vessel filled with water was used for cooling the lower contact sides of the elements. The entire battery has a length of 2 feet, a breadth of 6 inches, and a height of 6 inches.

M. Marcus communicated further that he had constructed a furnace which was intended for 768 elements. They represent a Bunsen's zinc carbon battery of thirty elements, and consume per diem 240 pounds of coal.—*Sitzungsbericht der Akademie in Wien*, No. 8, 1865.—*Philosophical Mag.*, vol. xxix., No. 197.

Petroleum as a Steam Fuel.

From the Practical Mechanic's Journal, March, 1865.

Under the above title a cotemporary journal, "*The Engineer*," (27th January, 1865,) utters a decisive condemnation of liquid fuels for steam navigation. The article, a leader, is powerful in the way of assertion, and, beyond measure, severe in its strictures on those who are here unorthodox in its eyes, all of whom are classed amongst those "who dabble a little in the laws of nature, and possess the unenviable notoriety of being amongst the most credulous of mankind." The man who seriously proposes to substitute liquid for solid coal as steamship fuel is, according to the writer, only worthy to be classed amongst the alchemists, if even his moral condition would entitle him to keep company with that very harmless class of enthusiasts, supposing any such to be in existence.

We must say this article seems to us written with much less than the usual discretion and ability of *The Engineer*, and to be one calculated to obstruct progress. It does not even cross the threshold of the real questions, upon the issue of which depends the success or otherwise of the attempts that will, notwithstanding its denunciations, be made to ascertain whether or not it be a fact, that real and great advantages must accrue whenever the means shall have become practically perfect for using liquid fuel for steam navigation.

It is nothing in point to urge that "dabblers in science" have attributed fabulous heating powers to petroleum, or other analogous liquid fuels. We are quite content to accept for the moment as ap-

proximately true the estimate of heating power given by the writer in *The Engineer*, and to assume that petroleum consists of about 85 carbon and 15 hydrogen by weight, and that steam coal, on the average, may be taken at 80 carbon and 5 hydrogen.

We are also willing, for the moment, to suppose that the estimate is correct as to the heating power of each fuel, based on the premises that the combustion of one lb. of pure carbon is equivalent to 11·194·000 foot pounds, and that that of an equal weight of hydrogen is four times as much. We are not to be understood as pledging ourselves to any of these figures, especially the last, which we deem largely below the truth. We simply take these data for the moment as presented to us, and accept *The Engineer's* conclusion from them—that the heating power of equal weights of petroleum and of coal are as 162 to 115 nearly, or as 1·4 to 1. This assumes, of course, that in both cases the combustion is *absolutely perfect.*

This alone does seem to us rather a striking *prima facie* case in favor of the petroleum—that its absolute heating power is admittedly nearly once and a half that of an equal weight of coal, But we have some elements to take into view before any such comparison can be practically even near the truth.

Petroleum may be viewed as simply a hydro-carbon; as *The Engineer* fairly puts it, 85 carbon + 15 hydrogen = 100. But the steam coal, as also fairly put by the writer, at 80 carbon + 5 hydrogen = 85, contains of oxygen, nitrogen, sulphur, and mainly ashes, no less than 15 per cent.

Now, no one will affirm that these incombustible parts are of any service whatever in the fire, although, if we burn coal, we cannot keep them out of the grate; hence, we must deduct at once fifteen per cent. of the absolute heating power in order to get the *practical heating value* of the coal. This would bring the relative heating values of the petroleum and coal to the ratio of 1·6 : 1. But there is a further correction. This 15 per cent. of ashes and inert matter in the steam coal, is not simply so much *useless or inert* material put on board and carried about—it is 15 per cent. of positively hurtful and waste-producing material, inasmuch as the whole of it must be heated up to the temperature of the furnace, and thrown off at that of the chimney; and to so heat it up, a certain increased portion of the otherwise available fuel must be burnt, just as in consuming wet wood one portion of the mass is burnt merely to evaporate the water out of the rest, and bring it to a state to burn and evolve its heat.

Now, dealing with the rough figures that we have here commenced with, it is not worth while to attempt any exactness as to how much of the 85 per cent. of real fuel in 100 lbs. of steam coal must be consumed to heat up to, say 2000° Fahrenheit, the 15 per cent. of rubbish it contains, very little of which ever comes back to the boiler. But, even when we shall have got this element into figures, we are not done with the coal. From the inevitable conditions of its combustion upon the set of grate bars, no precaution, no construction, can prevent more or less of the fuel dropping through into the ash-pit in an

unconsumed state, either as small coal, as coal dust, or as small cokes, These get mixed up with the ashes, *i. e.*, the really earthly contents of the fuel, and are with them thrown overboard.

We have, however, over and above all this, the losses produced by the imperfect combustion of the coal, and its sublimation, into the states of black soot and volatile oils (quite of the nature of petroleum) which fly up the funnel.

From the last three sources of loss, and others due to coaling and stowage, &c., together, the estimate recently given in the discussion of Captain Selwyn's paper on petroleum fuel, read at the United Service Institution, namely, that out of every five tons of steam coal purchased to be put on board, only four tons are really utilized, is one probably not materially in error. If this be so, as we are here comparing one fuel, (the liquid,) in which we will at present assume there is *no* waste, with the other, coal, upon which there is a waste of one-fifth, so may we at once add one-fifth to the absolute heating power of the petroleum, as representing then its practical efficiency as compared with coal. We then have, in relative value as fuel, petroleum : coal :: 2·68 : 1·00, or for equal effects.

Let us now come to the question of stowage. *The Engineer* admits 48 cubic feet for the ton of coal, and 44 cubic feet for the ton of petroleum. Accepting again these data, we find that *equal bulks* of petroleum and of coal, when stowed on board, will produce useful effects as fuel, in the ratio of 1·83 : 1·00. In other words, heating power and stowage considered together, the petroleum is *nearly twice the value* of coal for steam navigation.

But we are not done yet with the comparison. As the tonnage of any steamship is a constant quantity, whatever we save in stowage of fuel may be devoted to stowage of cargo, and thus we may either increase our power and our speed in a ratio approaching that of 1·83 to 1·00, or, at the old power and speed, we may stow additional cargo to the extent of about one-half of the bulk of the original coal bunkers. This will be *paying* cargo, and as a result, we must carry to the credit of the petroleum a still further augmentation of its figure of value, the precise amount of which can only be determined by the conditions, mercantile and otherwise, of any given example.

We have deduced everything thus from the data admitted by the writer in *The Engineer*, and we are quite content with the result. Were we, however, to proceed to what we should deem a precise and trustworthy comparison, upon more exact data, the case would assume even more favorable conditions as respects liquid fuel.

We have said that we have assumed no waste with liquid fuel. We have rightly done so, for with such fuel waste is impossible. It *must* be *perfectly* burnt, or accidents must result. It must not be spilled about or lost, or leaked away for the very same reason.

It thus becomes quite absurd and beside the point to make objection to the future practicability of using this liquid fuel, *based* on the *assumption* that it is to be stowed in our existing construction of ships, and burnt in our existing types of boilers and furnaces. Nor is this a

question that admits of being justly considered upon the basis of mere theoretic proportionate value of petroleum and of coal. It is eminently a practical question, and, like all such questions, is full of compromises and conditions balancing and affecting each other, the total of which must be taken into account. Thus, for example, a steamboat running short trips, with intervals of rest, can at present do no more than bank the fires, and cover the funnel top in such intervals, but the mass of fuel is alight, and, do what we may, will slowly consume, or go out altogether. If petroleum be the fuel, the flame can be shut off like a gas-light, or brought to a point only just to keep up steam. Here *may* be great economy; here may be advantages for war purposes scarce calculable, yet this is but an adventitious condition affecting differently the two fuels, whether they are relatively, *per se*, theoretically good or bad.

The stowage of petroleum must be in cells—not tanks—formed between an inner and outer skin of the bottom of iron ships, and divided by the continuous keelsons, and by several cross diaphragms. No practical engineer can be found who will deny the perfect facility with which such cells can be made vapor tight, even against a considerable tension; nor that any mechanical difficulties will be experienced in providing these with valves and cocks, &c., by which each can be filled and emptied separately if desired; and with the means of knowing precisely the volume, temperature, and state of the liquid within each, without access to or opening into the interior. Whether such closed cells be quite full or nearly empty, or whether their contents be churned or shaken up by the most heavily pitching or rolling ship or not, matters nothing.

The petroleum must be pumped in, or passed in any case through appropriate mains; and to make it available as fuel on board, measured volumes of it must be continually pumped out, and delivered at the point of combustion. Arrived there, it must be *met by measured volumes of air*, whose current through the flues and up the funnel must never intermit. In one word, the petroleum brought into a state of vapor must, at the point of ignition, be brought into contact with the requisite volume of air; and the combustion must be perfect—devoid of all smoke, like the flame of a well-trimmed naphtha lamp, and equally devoid of waste, by being mixed with a needless volume of air.

To effect these conditions, it is scarcely necessary to say that our present types of marine boilers are wholly unsuited. No alterations possible on existing boilers will meet all the requirements; for special apparatus is required, not only for the combustion of a fuel, the whole of which will disappear in flame, but for the absorption of the intense heat poured forth with great rapidity by this flame.

Marine boilers for the economical consumption of petroleum fuel must be contrived that shall admit of the entire length of these flues or tubes—from the first combustion point to the base of the funnel being constantly filled with a brilliant and intense *flame*, and the water spaces, etc., must be so arranged as to permit free escape to

the increased volumes of steam that will be delivered from surfaces thus rapidly receptive of heat.

The temperature of hydro-carbon flame, when perfect, is probably not inferior to that of the ignited solid fuel in the marine boiler furnace, if not superior to it. There will be a vast difference in steam producing power, within the same total bulk of marine boiler, between the best existing types, in which the gases of the fires meander through the soot and dust-lined flues and tubes at an average temperature of only about a low red heat at best, and a new type, constructed with great receptive surfaces, always rigidly clean, and free from jacketting inside with soot or dust, and filled with flame from end to end, as bright and hot as that of an oil gas argand burner.

This is a thing of the future, no doubt, but it presents nothing impracticable, because nothing contrary to nature's laws; nor does its accomplishment present anything like the difficulties that beset every attempt to "consume smoke" from coal on board steamships. To effect this, real difficulties are imposed by the very nature of the solid fuel, and the necessity of passing through it an enormous and unmeasured volume of air, which have no existence in respect of liquid fuel.

In the very rough comparison of effective value we have made, based upon our respected cotemporary's data, we have not alluded to the enormously better boilers for economizing heat, that liquid fuel will not only admit of, but compel. At present every part of flue or tube must not only be so circumstanced that it can be got at for repair; it must be also capable of being swept or brushed free of soot and ashes. The draft, as at present produced by a low funnel, almost always inadequate to perfect combustion of coal fuel, involves likewise large flue or tube areas, the surfaces of which are always sullied, so as to be bad absorbers of heat.

Except as respects capability of repair, all these arrangements may be changed; and, with surface condensation and fresh water in the boilers, the construction of the latter may take the type of the locomotive, with enormous and most effective expansions of tube surface. Artificial drafts, however produced, will be found, we think, indispensable; and as a result, the existing huge, lumbering funnels, rising 30 or 40 feet above the deck, will disappear, and their place be supplied by comparatively small tubes, just enough to emit the transparent water vapor, carbonic acid and nitrogen, which will constitute the bulk of the evolved products of the combustion. These tubes need not rise above the deck higher than shall carry these vapors or gases clear of persons on deck. There will be no smoke.

Hitherto we have alluded only to the advantages in a mercantile sense, consequent upon the successful use of liquid fuel for steam navigation. For purposes of naval warfare, however, its advantages can scarcely be at present fully foreseen.

If liquid fuel be weight for weight about twice the efficient value of coal, then a blockading steamship can keep her post off an enemy's coast twice as long without replenishment, using such fuel, as if she

used coal; or, she can make twice as long an ocean run as with coal. No column of smoke streaking the horizon will tell of her presence, before she desires, to an enemy watching to escape.

We have used the word petroleum throughout here, because shortly it expresses, though badly, what we are treating of.

We look however to the future of liquid fuel taking its supply, not from natural oil wells, or at least not from these alone, but from liquid hydro-carbons, to be artificially produced by the distillation at low temperatures (not exceeding a low red heat) of the very worst and most worthless refuse small coal of our coal fields. Fuel thus at present absolutely and heedlessly wasted, such as the mountains of small coal and dust at the pit-heads of most of the northern collieries, will become convertible in part into a combustible of the highest value, and of the greatest portability. We have no doubt, too, that in the time to come, though yet a distant one, means, the general nature of which we can even already discern, will be devised by which our *very* thin seams of coal, such as those of Staffordshire, that are too thin to bear the cost of working at all, by ordinary methods, shall be so arranged that by their own slow combustion *in situ*, when once set alight, and supplied in proper air courses and galleries by downcast shafts with suitable volumes of air, they shall evolve at the mouths of upcasts immense volumes of hydro-carbon vapors, only requiring condensation to fit them for liquid fuel.

To the savage man, fuel of any sort, or its use, are incomprehensible mysteries; to a not very remote generation of our own ancestors, coal, as a substitute for wood or peat, was held a mischievous and deleterious refinement; to some at the present moment, the substitution of liquid coal (for what is petroleum but that minus a little carbon?) presents itself as an equally absurd and preposterous, because new, attempt. Yet we venture to predict that a not *very* distant age will see coal as fuel employed in no other shapes, but after preparation, and either as liquid hydro-carbon distilled from the raw coal, or as carbonic oxide and other combustible gasses produced from it, and used alone as fuel, by methods analogous to those of Mr. Charles Siemens.—Ed.

Platinum Mirrors.

From the London Journal of Science, July, 1865.

M. Dode, a French chemist has introduced platinum mirrors, which are greatly admired, and which present this advantage, that the reflecting metal is deposited on the outer surface of the glass, and thus any defect in the latter is concealed. The process, which is patented in France, is described as follows: Chloride of platinum is first made by dissolving the metal in *aqua regia* and driving off the excess of acid. The neutral chloride is then dissolved in water, and a certain quantity of oil of lavender is added to the solution. The platinum immediately leaves the aqueous solution and passes to the oil, which

holds it in suspension in a finely divided state. To the oil so charged the author adds litharge and borate of lead, and paints a thin coat of this mixture over the surface of the glass, which is then carried to a proper furnace. At a red heat the litharge and borate of lead are fused, and cause the adhesion of the platinum to the softened glass. The process is very expeditious. A single baking, M. Dode says, will furnish 200 metres of glass ready for commerce. It would take fifteen days, he says, to coat the same extent with mercury by the ordinary plan.

Preservation and Amelioration of Wines by Heat.

Accepting the theory of M. Pasteur that the deterioration of wines is caused by the propagation of certain mycoderms, M. de Vergnette-Lamotte experimented on the effect of a high temperature continued for a considerable time upon the French wines. The effect of high atmospheric temperature upon Sherry and Madeira has long been known and made available by connoisseurs. A number of bottles of Burgundy, containing 12·8 per cent. of alcohol, and of a fine reddish violet color, were exposed for two months to a temperature which was not allowed to exceed 122° Fahrenheit, (50° Centigrade.) The wine had lost its color and its fruity savour, and somewhat resembled the Spanish wines. By prolonging the experiment for a year, the wine had entirely lost its color and had taken the tint known as onion-skin; it had deposited abundantly, and appears to be entirely preserved, while the bottles of the same lot which had been left in the cellar without heating, had become sickly and was worthless. It is doubtful whether a process by which a Burgundy wine is converted into something resembling Sherry will meet with much favor in France.

Erosion of Lead.

From the London Mechanics' Magazine, August, 1865.

The erosion of lead, and even of type metal, by certain species of insects, is not generally known, and may be extremely mischievous. Not long ago it attracted the attention of the French Academy of Sciences, and several communications respecting it have been published with their proceedings in the *Comptes Rendus*. Of these the following is a *resume:* In 1858 Marshal Vaillant exhibited to the Academy leaden bullets brought back from the Crimea, in some of which the larvæ of insects had excavated circular passages three or four millimetres in diameter, and in others superficial grooves. Inquiry was made through the Russian Ambassador, M. de Kisselef, whether similar erosion had been observed in Russia. M. V. de Motschulsky replied that nothing of the kind had been detected in the cartridges of the Russian army in the Crimea, and that the insect which had caused the injury appeared to be very rare in Russia, not having been discovered by Russian entomologists in the Crimea. It is stated to be very common in England, Sweden, and Germany, and

to occur in the Jura in France. It attacks silver firs and pines. The insect which damaged the French cartridges was imported from France in the wood of the cases in which they were packed. All the excavated passages were originally circular in section, and those that were semi-circular in section, that is, superficially grooved, were only segments, of which the other half was in the contiguous surface of other bullets, or of the wood forming the sides of the cases. The passages were always open at both ends. Excavation was effected by the mandibles of the insect, the apparatus consisting of a saw-tooth, and cut like a file. The insects do not eat the lead, but simply bore it out; and it was observed that their remains, after metamorphosis, had been carried downwards by the particles of the metal, reduced to powders, and dispersed on the outside through the cracks, in the bottom of the packing case. The perfect insects did not attack the lead, but died in the passages, even immediately after their complete metamorphosis, as very often occurs with insects in general.

In 1833 Audouin exhibited to the Entomological Society of Paris sheet lead from the roof of a building deeply grooved by insects. In 1844 Desmarest mentioned erosions and perforations of sheet lead by a species of Bostriche, and illustrated the fact by cartridges from the arsenal at Turin. Mr. Westwood, the well-known British entomologist, has recorded observations by himself on the perforation of lead by insects. M. Bouteille, curator of the Museum of Natural History at Grenoble, sent to the French Academy of Sciences, from the collection under his charge, specimens of cartridges gnawed by insects, which were found *in situ*, and the following report upon the subject was made by Marshall Vaillant, de Quatrefages, and Milne Edwards: The insect *Sirez gigas*, a large hymenopterous species, which, in the larvæ state, lives in the interior of old trees or pieces of wood, and which, after the completion of its metamorphosis, quits its retreat for the purpose of reproduction. As previously stated it cuts its way by its mandibles, gnawing the woody substance or other hard bodies which it meets with in its course. Analogous perforations are made by the mandibles of the *Callidium sanguineum*. The reporters add: "If it is probable that it is always with their mandibles that coleopterous as well as hymenopterous insects thus attack lead or other hard bodies, it is not well established that it is always the desire of liberty which prompts them so to act. Indeed, in some cases, coleopterous insects have been seen to gnaw the exterior of similar bodies." Reference was made to a paper by Antonio Berti on the perforation of leaden pipes by an insect named *Apate humeralis*.

Scheurer-Kestner, in 1861, communicated to the French Academy a notice of the erosion by an insect of the sheet lead of a new sulphuric acid chamber. The creature was caught in the act of escaping through the lead, having been imprisoned between it and a wooden support. Perhaps the most interesting and important case of insect erosion is that of stereotype metal, which was communicated in 1843, by M. du Boys, to the Agricultural Society of Limoges. Specimens riddled were also exhibited.

On the Specific Refractive Energies of the Elements and their Compounds.

From the London Chemical News, No. 286.

DR. J. H. GLADSTONE delivered a discourse in which he described the further results of the conjoint labors of himself and the Rev. T. P. Dale, M. A., in a branch of physical research which had been already sketched out in a paper read before the Royal Society, in March, 1863. Since the date of this communication, the subject had been taken in hand by Landolt, who adopted a mode of working very similar to that of the author's. The "specific refractive energy" of a body is a constant, not affected by the temperature, and is arrived at by dividing the refractive index of the substance (μ) minus 1, by the density. The formula already proposed was found to hold good on a more extended investigation of the subject, and the authors generally worked with the fixed line A. The proposition resolved itself into a study of the inquiry whether the specific refractive energy of an element was invariable under all circumstances of isolation or combination, and whether this property in the case of a compound was correctly expressed by taking the means of the refractive energies of its several elementary constituents. As a general rule this was found to be the case, but the authors brought forward a few exceptional instances which at present appeared to stand in opposition to their statement. Dr. Gladstone particularly referred to sulphurous acids, and aqueous tartaric acid, as presenting anomalies which were considered worthy of more extended investigation, with the view of determining the nature of the disturbing causes. This mode of physical research was interesting in connexion with the study of isomerism, and would probably lend valuable aid in determining the internal constitution of bodies; thus, whilst aniline and its isomer, picoline, gave widely different results under this optical treatment, it had been found by Landolt that a mixture of equal equivalents of methylic alcohol and acetic acid behaved precisely like its theoretical conjugate, glycerine! Dr. Gladstone exhibited in a tabulated form the numbers representing the specific refractive energies of many of the elements, multiplied by their atomic weights, or "refraction equivalents," as Landolt terms it, and he worked several examples by way of showing the application of the formula, and the mode of deducing from compound bodies the value of each constituent. The table stood thus:

Name of element.	Refraction equivalent.
Carbon,	5·1
Hydrogen,	1·5
Oxygen,	3·0
Nitrogen,	3·3
Chlorine,	8·5
Bromine,	15·7
Iodine,	24·4
Sulphur,	16·0
Phosphorus,	18·6
Tin,	22·0
Sodium,	6·0
Mercury,	11·0

With regard to the valve of carbon it was shown that the number observed in the case of the diamond agreed with the results deduced from the examination of carbonic oxide, carbonic acid, olefiant gas, and a variety of liquid hydro-carbons. Hydrogen did not appear to have precisely the same value in the form of gas that it had in certain hydrogen compounds, and the author stated that 7·6 was the average expression from a great number of experiments, of the value of $C H_2$, the oft-quoted increment of carbon aud hydrogen in the homologous series. Nitrogen in the form of gas was 3·3 as above, but in combination its value sometimes amounted to 4·2. In a similar manner the numbers representing oxygen and chlorine gases became subject to modification when those elements were combined.

The PRESIDENT said he had listened with much pleasure to the author's interesting communication, and he wished now to inquire of Dr. Gladstone whether there appeared to be any relation between the remarkable exceptions noticed by him, and their observed atomic volume. It was known that oxygen in combination occupied two different atomic volumes, and he thought it possible that there might be some connexion between the volume and refractive energy in this and other similar instances.

The Rev. THOMAS PELHAM DALE gave an account of the mode by which these conclusions had been arrived at, stating that Dr. Gladstone usually undertook the experimental, and himself the mathematical department of the inquiry. The formula adhered to in calculating the refractive valve was

$$\text{I}\,\frac{\eta - 1}{d} = c,$$

and the speaker insisted upon the importance of selecting bodies of refractive indices—such as bisulphide of carbon—for the purpose of testing the accuracy of the proposed theory. The liquid named was readily procured and purified, and its refractive index for the red rays was 1·6, and for the violet 1·7. Errors might arise from inaccuracies of adjustment, or from an elevation of temperature in the liquid contents of the prism by the passage of the solar beam; but Dr. Gladstone had employed a liquid septum—such as alum solution—in order to cut off the heat rays, and it was not possible that the figure of the hollow prism underwent any sensible alteration during the experiments, inasmuch as frequent observations made with the same liquid gave closely concordant results. He would, however, recommend the use of a prism of 60 degrees, or an equilateral triangle, and make three independent observations, changing the angle each time, and then take the mean of the three results.

Dr. FRANKLAND had hoped that the optical results would have suggested an explanation of the difference observed in the chemical properties of carbon in the form of carbonic oxide, and the more active state of that element existing in combination with hydrogen in olefiant or marsh gas. It appeared that the specific refractive energy remained constant throughout, and that optically there was no distinction between one and the other form of carbon.

Dr. GLADSTONE replied that his experiments did not indicate the well marked chemical difference to which Dr. Frankland had alluded. The speaker offered some further remarks with reference to the details of the optical arrangement, and stated that M. Landolt and Professor Stokes had seen no theoretical difficulty in accepting the proposed formula.

The PRESIDENT then moved a vote of thanks to Dr. Gladstone and Mr. Dale for their interesting communication, which was warmly responded to, and adjourned the meeting until June 1, on which occasion he would have the honor of addressing the Society upon the subject of "*The Analysis of Potable Waters.*"

Lead Poisoning.

From the London Mechanics' Magazine, August, 1865.

Poisoning by drinking water which has acted on lead, happens far more frequently than is often suspected, and the mode in which the water is rendered poisonous is frequently difficult of discovery. A correspondent of the *Times* states that, from a rural parish where the drinking water is got from draw wells, and there are neither leaden pipes pumps nor leaden pipes to contaminate the water, several of the peasantry went lately to the neighboring county infirmary suffering from lead poisoning. Careful investigation led to the discovery of the evil—the so-called "tinned" kettles in which the water used for tea and for cooking was boiled. It was ascertained that the "tin" with which the kettles were lined was an amalgam of tin and lead. The adulteration of tin with lead is one of the most common frauds. It is of very great importance to public health that some way of escaping from poisoning by leaded tin should be discovered, and it would be desirable that we should know whether there is any coating for iron which would resist heat and the ordinary action of water, and which could be substituted for what is called "tin." About a year ago a French patent was taken out for such a coating, and the coating is said to have stood very severe tests of heat and acids. Such a coating has also been discovered lately in England. Any one giving accurate information respecting such coatings, would confer a boon upon the public. A very ready test for lead in water consists in taking two tumblers and filling one with water which is known not to have been in contact with lead, the other being filled with the suspected water. Dissolve in each about as much bichromate of potash as will stand on a groat. By daylight the water in each tumbler will be of the color of pale sherry and water. Cover the tumblers so as to keep out dust, and let them stand in a warm place in a room with a fire in it for twenty-four hours. If the suspected water be free from lead, it will still have the same color as the other, but if there be lead in the water, it will have a more or less opalescent tint, as if a drop or more of milk had been put into it. If there be a great quantity of lead in the water, a very slight film of lead will be deposited on the glass.

For the Journal of the Franklin Institute.

Atmospheric Pressure as a source of Mechanical Power.

In the concluding paper on this subject in the July number of the *Journal*, a passage was accidentally omitted in the copy sent. Its point is too pertinent, if not too important, to be entirely excluded:

It was observed that the two forces in steam bear the same relation to each other as action and reaction—that in a cylinder with a piston of fifty inches area, and worked with steam of four atmospheres, or 60 lbs. on the inch, the pressure on the piston would be $50 \times 60 =$ 3000 lbs. On the other hand, the fluid on leaving the cylinder would dilate and fill four of the same dimensions; hence $50 \times 4 \times 15 =$ 3000 lbs. of atmospheric pressure. But while the forces are theoretically equal, in practice the contracting one is (what few would suspect) the most productive, and, in some cases, to an extent that not many would credit. The truth, however, is that more power—15 lbs. on the inch more—may be obtained from condensing steam of two atmospheres and upwards, than from its direct pressure. This signal result is due to the fact that a cylinderful of low or common steam has no expansive power at all to move the piston, while it is all that is required to produce a vacuum under it. In the above example the acting expansive force is credited at 3000 lbs., but in reality it should be held at 2250 lbs., for, as the piston acts against the pressure of the atmosphere, 15 lbs per inch is consumed in overcoming that, leaving, as the effective force, 45 lbs on the inch, instead of 60 lbs. It is, therefore, palpable that at every stroke of a piston moving by the direct pressure of the fluid, a cylinderful of it of one atmosphere, or of 15 lbs. on the inch, is virtually lost.

The piston of an engine working with steam of two atmospheres, or 30 lbs. on the inch, has only 15 lbs. productive pressure, while the condensation of the fluid produces a vacuum under a piston of twice the area of the other, thus evolving a force by condensation actually double that of expansion.

Another fact to which I do not remember to have seen any reference: When expansion by cut-offs in the working cylinders of the present condensing engines is not carried down to zero—something bordering on the impracticable—all the steam over and above that, is not only lost, but the expense of its condensation thrown away. Were this source of waste of fuel, and of power thoroughly laid open, (see Mr. Lewell's remarks, page 39,) it would be startling. By the plan proposed—see July number of the *Journal*—it is annihilated.

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Strength of Steam Boilers.

From the London Artizan, August, 1865.

In another column our readers will observe the reported explosion of a large Cornish boiler, and as this appears to have been due to deficiency of strength originally in the flue tube, it appears to us not

inappropriate to offer some remarks as to what course should have been adopted in order that the boiler might be competent to withstand the ordinary pressure to which it was intended to subject it. The locus of failure was in the internal tube, which was far too weak to bear the strain, which was "50 lbs. and upwards per square inch," the dimensions being as follows: Internal tube, 4 feet in diameter, 32 feet in length, and $\frac{7}{16}$ of an inch in thickness. This tube collapsed completely from one end to the other, as the calculations given below will show was the result to have been anticipated.

There were two ways in which the flue might have been made stronger; first, by using thicker plates in its construction; second, by attaching stiffening rings to support it, virtually, in fact, dividing it into a series of shorter tubes, and so increasing its strength.

The formula used below is a *practical* one for *working* strength based upon the data obtained by Mr. William Fairbairn, C.E., from his experiments upon the resistance of tubes to collapse under external pressure.

Let t = thickness of metal in inches.
l = length of flue in feet.
d = diameter of flue in inches.
p = pressure in lbs. per square inch.

Then,

$$t = \sqrt{\frac{p\,l\,d}{161200}}.$$

First, taking the flue as not being stiffened by rings, the thickness of metal requisite would be thus determined,

$$t = \sqrt{\frac{50 \text{ lbs.} \times 32 \text{ ft.} \times 48 \text{ in.}}{161200}} = \sqrt{\cdot 476 \text{ in.}}$$

and

$$\sqrt{\cdot 476} = \cdot 6902 = \frac{10 \cdot 04}{16} \text{ in.},$$

whereas the actual thickness, as stated above, was but $\frac{7}{16}$ in.

The actual pressure which might have been safely put upon the flue may be determined by transforming the formula thus,

$$p = \frac{161200\,t^2}{l\,d}$$

in the present case,

$$p = \frac{161200 \times 49}{10 \times 48 \times 256} = 20 \text{ lbs. nearly},$$

and this is, probably, as high a pressure as such a flue should have been regularly exposed to.

If the thickness of $\frac{7}{16}$ in. had been retained, and the tube strengthened by the second method, inserting stiffening rings, so as to reduce

the effective length of the flue as regards its resistance to external pressure to 10 feet in each length, the safe working pressure would have been

$$p = \frac{161200 \times 49}{32 \times 48 \times 256} = 64 \text{ lbs. nearly.}$$

It is here worthy of comment that there appears to be a great tendency to overstrain the materials used in the manufacture of boilers, which does not occur in the construction of other works wherein the same materials are used, although, as in the case of iron bridges, the risks would probably be less in reducing the strength, than in making boilers too weak; but then, it is to be remembered that iron railway bridges are always subject to severe tests, and undergo a rigid examination by a government inspector before they are allowed to be applied to public use; and it seems very desirable that some similar course should be adopted in regard to boilers, whereby a considerable diminution of loss of life, &c., might be effected.

It is tolerably certain that there are many cases of boiler explosions in which the boiler itself has been amply strong, the accidents being due to a combination of circumstances quite unanticipated and beyond control, but such an explosion as that above alluded to, can only be traced to neglect of the proper precautions which should have been adopted in the construction of the apparatus.

Furthermore, in the comparison of bridges with boilers, it is evident the latter are much more liable to deteriorate in the strength of their materials than the former, as the influences to which they are subject are of a more destructive character than those which affect the former, while their depredations, being out of sight, are exceedingly liable to be overlooked, until they have progressed to such an extent that they render themselves evident by giving rise to some appalling accident.

Of course, a frequent systematic examination will do much towards the diminution of the number of explosions, and it is not improbable that in the accident above referred to, some depression in the tube might have been noticed previous to the total collapse, in which case, by the application of proper means—such as stiffening rings—the catastrophe might have been avoided and the flue rendered safe.

Such occurrences supply valuable experiences which *ought not* to be lost upon manufacturers and users of steam apparatus, but it is to be feared that, as a rule, they produce but temporary impressions, passing away with the remembrance of the accidents creating them.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, September 20th, 1865.

The meeting was called to order with Prof. John F. Frazer, Vice President, in the chair. The minutes of the last meeting were read and approved. The minutes of the Board of Managers and of the various

Standing Committees were reported, including the following donations: From the Royal Geographical Society, the Royal Astronomical Society, the Statistical Society, the Institute of Actuaries, and the Zoological Society, London; Col. Richard Strachy, through the Asiatic Society of Bengal, Calcutta; the Canadian Institute, Toronto; the Natural History Society, Montreal; the Literary and Historical Society, Quebec, Canada; and Wm. Biddle, Sol. W. Roberts, and Professor John F. Frazer, Philadelphia.

The Special Committee on Steam Expansion reported progress of their experiments.

The usual special paper for the evening was omitted through the unavoidable absence of the gentleman who had been appointed to read it.

The report of the Secretary on new inventions and discoveries was then in order and was read as follows:

Secretary's Report.

Mechanics.—We have received a communication from Mr. T. McDonough, of New York, on the subject of certain experiments in the effect of mixing air with low pressure steam.

The apparatus used was of a simple form. Steam was generated in a small boiler and allowed to escape through a nozzle so as to strike upon the fans of a little air-mill. The quantity of steam escaping in a given time, and the number of revolutions produced in the air-mill by this means were determined in the first place by direct experiment.

Air from a gas holder under moderate pressure was then allowed to flow into the rear of the same jet and issue with the steam.

The amount of air so added, and the number of revolutions in the air-mill during a given time being again determined, it was thus found that the addition of a small amount of air, say $\frac{1}{10}$ that of the steam, would increase the number of revolutions in the mill by a much greater quantity, as in this case by $\frac{1}{4}$.

The following table will exhibit the result of many experiments:

Table *of Experiments in Mixing Air and Steam.*

Revolutions of wheel per minute,	60	60	60	60	60	60	60	60	60	70	60	84	60	86
Cubic inches of steam per minute,	432	432	432	432	432	432	432	432	432	504	432	604	432	619
Inches of air added per minute,	43	60	83	120	150	200	40	66	55	85	66	100	85	120
Motion of wheel with steam and air,	73	90	91	120	165	164	74	107	98	111	80	180	99	150
Gain by adding air over what is due to increased volume,	0·29	·23	·17	·37	·61	·56	·39	·44	·30		·25		·14	·32

Example.—In first column, by adding 43 inches of air to 432 of steam, the wheel increases its speed from 60 to 73, or about one-quarter for an added volume of one-tenth.

This action it is, moreover, proposed to apply to steam engines by so arranging the valves, &c., that air in place of steam will be admitted during the first part of the stroke, after which the steam will be admitted and mix with this air.

We should remark in this connexion that the above experiments and results do not stand alone, but are supported by other independent

investigations. Thus, similar facts have been observed in connexion with a small steam turbine, by Prof. R. E. Rogers, of the University of Pennsylvania, and a plan for using air and steam together mentioned in the London *Mechanics' Magazine*, January, 1865, page 7, points to some observations in the same direction.

In explanation of some of these experiments, it may be suggested that the introduction of cold air might condense some portion of the steam, so causing it to be projected in liquid drops against the wheel, by which means its motive power would be more efficiently applied than when it issued as an expanding and diffusable vapor.

Mr. NYSTROM here remarked that the increased density of the mixed air and steam might account for the gain in effect.

The apparatus referred to above was explained by means of a drawing made upon a plate of glass (coated with a colodion film, which had been sensitized, exposed, and developed in the usual manner) placed in a powerful lantern, by which a greatly magnified image was thrown upon a screen conveniently adjusted, and thus made distinctly visible to all in the room. The apparatus next to be described was illustrated in like manner, and it is the intention of the Institute to place this mode of demonstration at the command of all who may require it at their meetings.

The next point noticed under the head of "mechanics" was the low water signal of Shaw and Justice. This consists of an ordinary steam whistle attached to the boiler by a tube reaching to the lowest safe water line, and having those parts immediately below the bell of the whistle, filled with resin. So long as the water line in the boiler is above the lowest safe level, the tube leading to the whistle is filled with that fluid, which, by reason of its restrained circulation, &c., will not carry up heat enough to melt the resin. When, however, the water falls below this point steam enters the tube, melts out the resin, and blows the whistle.

Glass Etchings.—At a previous meeting, the process by which crystals might be produced on plates of glass and their designs then etched into that substance, so elaborately studied by Kuhlman, had been described and specimens exhibited. It had since been found that such etchings formed beautiful objects for the magic lantern, the difference between the roughened and smooth portions producing on the screen all the distinction between black and white, with every variety of half tone and gradation.

(A number of these specimens, and the plates coated with crystals from which they were formed, were here exhibited in the lantern.)

Physics.—Many experiments have been made by Professor G. F. Ansell, of the Royal Mint, London, on the diffusion of burning gas and its kindred substances, fire, damp, &c., through various porous substances, including porous earthenware, graphite, and india rubber, with a view of arranging a piece of apparatus which might serve as an indicator of such dangerous substances when present in coal mines and other localities. Several instruments of different forms have been devised, all, however, alike in their dependence upon a well known action,

by which rare gases as a rule pass through a porous diaphragm into denser ones more rapidly than these last travel in the opposite direction.

By this means, if a vessel filled with air is closed by a porous plate or stopper as above described, and is introduced in an atmosphere of burning gas or the like, this last will enter the vessel more rapidly than the air will escape, so producing a pressure readily indicated by a water gauge or like instrument, which thus serves as an indicator of the gas in question.

India rubber, it appears from the above experiments, is decidedly pervious to burning gas; which shows us that the leakage of flexible gas pipes, so often complained of, is not always a fault of manufacture, but to some extent an unavoidable nuisance.

(The diffusion of burning gas through porous substances was here experimentally demonstrated.)

Spectrum Analysis of Heavenly Bodies.—In a previous report published in the June number of this *Journal*, we noticed some remarkable facts in relation to nebulæ which were pointed out in a communication to the Royal Society by William Huggins. From a more complete abstract of this paper we now call attention to some additional points of interest.

It would appear that out of some fifty stars, whose spectral lines were carefully studied, only two, α Orionis and β Pegasi, want the very distinct lines C and F, which indicate the presence of hydrogen. The lines which indicate sodium, magnesium, and iron seem universal, while there is much difference with regard to others.

There seems also reason to believe that the color of stars and planets may in some sort indicate the chemical condition of their atmospheres. Thus, in the planet Mars we find that the predominance of red light may be due to strongly marked groups of dark lines crossing the blue end of the spectrum, and indicating bodies which cut off these rays, and so leave the red vibrations unbalanced and in excess.

The same connexion has been observed between the spectra and tints of many colored stars, and is especially remarkable in the double star β Cygni, whose components are orange and blue, and whose spectra abound in dark lines across the blue end for the first, and across the red and yellow for the second.

Certain nebulæ, as was before stated, show in the spectroscope bright lines indicating a gaseous state, in place of the continuous spectrum crossed by black lines, which denotes a luminous solid, enveloped in a gaseous atmosphere. Some of these, as the great nebulæ in Orion, show three bright lines, of which two correspond with the brighter lines in the spectra of hydrogen and nitrogen respectively, the third not corresponding with any known element.

The annular nebula in Lyra and the dumb-bell nebula show only the line which indicates nitrogen.

In these cases what we may call the nitrogen spectrum, as given by the nebulæ, wants some bright lines which we might expect to see. The elementary character of this substance has often been questioned on chemical grounds. May this spectrum indicate the element of which nitrogen is a compound?

Electricity.—A new arrangement for developing electricity of high tension is announced by Prof. Julius Thompson, of Denmark.

The apparatus consists of a series of platinum or platinized plates, immersed in dilute sulphuric acid, charged in succession by causing an ordinary battery to pass its current through them, so as to develop oxygen and hydrogen respectively on alternate plates; they then act on the principle of Grove's gas battery. The transfer of the action of the charging battery from pair to pair of this platinum series is effected by a little magneto-electric machine, and is continued as long as the apparatus is in motion.

Glissler Tubes.—The manufacture of these beautiful pieces of apparatus still continues to improve. Larger and more beautiful combinations of form and color are continually appearing.

Two very beautiful specimens, imported by Chester & Co. of New York, were exhibited. One of these, nearly a yard in length, contained eight bulbs of canary glass, which, by reason of their fluorescent properties, glowed in the electric discharge like a string of emeralds. Another contained a colorless solution of quinine, to which, however, a beautiful blue color was imparted by its fluorescent action from the electric discharge.

Mr. COLEMAN SELLERS remarked in this connexion, that, as was well known, these fluorescent bodies shone at the expense of the invisible but actinic or photographic rays, which they thus rendered visible by depriving of their especial properties and powers.

That this property was applied as follows: A plate of glass coated with a solution of quinine was substituted for yellow glass in photographic dark rooms, &c., and this, while allowing white light to pass, deprived it of its actinic power, and rendered it innocuous to sensitized plates.

Chemistry.—New processes for the preparation of oxygen. In the *Analen der Chemie and Pharmacie* for last April, appeared an article describing the following process for oxygen, by M. Fleitmann, which has been very thoroughly quoted in scientific and other journals: "Commercial chloride of lime, or bleaching salt, is treated with water, by which all its hypochlorite of lime (CaO,ClO) is dissolved. This solution is then decanted, and has a small quantity of the hydrated sesquioxide of cobalt mixed with it, and then being heated to 70° or or 80° Fahrenheit, disengages gently all the oxygen it contains. The same oxide kept moist may be used over again with fresh solution as often as desired. Oxide of nickel acts in a similar manner, but with less energy."

The action here described is a very remarkable one. The office of the oxide of cobalt being simply to take oxygen from the lime salt, and immediately to abandon it while returning for a fresh supply. The action is also curious from the ease with which it takes place, as is thus shown: We pour into this test tube a little of the lime solution, and then add a few drops of nitrate of cobalt. A black precipitate is at once formed, and immediately, without any application of heat, the liquid froths and gives off a gas which we easily prove to be oxygen by its power of relighting a smouldering match each time we introduce it into the mouth of the tube.

This action is peculiarly striking to the experienced chemist, who is accustomed to see oxygen liberated only by the application of a high temperature and with comparative difficulty. This process has been generally announced as a very economical one, far cheaper than the usual method with chlorate of potash, but our experiments do not support this idea. One pound of chloride of lime will yield but about $2\frac{1}{2}$ gallons of oxygen, while one pound of chlorate of potash yields about 30 gallons or 12 times as much. The cost of the materials is in the same proportion inverted, which makes the cost for the same quantity of oxygen equal in the two methods.

As regards convenience, the balance is decidedly against the new process. Each pound of the lime salt requires about a quart of water for its treatment, and we thus have the unwieldy bulk of nearly three gallons to deal with, while a pound of chlorate can be readily worked in a quart copper flask.

If we could obtain the liquid chloride of lime, (manufactured abroad but never imported,) which contains a double proportion of hypochlorite, this process would be of economic value. Our native limestones are found unfit for the manufacture of bleaching salts on account of the magnesia which is present in all of them.

Another process for oxygen is announced by M. Archereau of Paris. This consists in exposing a mixture of silica (sand) and sulphate of lime (burned plaster) to an intense heat in a peculiar furnace somewhat like Siemen's, when a silicate of lime is formed and a mixture of sulphurous acid and oxygen escapes,

$$SiO_2 + CaO,SO_3 = CaO,SiO_2 + SO_2 + O.$$

It is proposed to remove the sulphurous acid by subjecting the gases to a pressure of three atmospheres by which this gas is liquefied, which will facilitate the removal of the greater part, and absorbing the remainder in milk of lime.

It is stated that this process will furnish the gas at so low a rate, that it may be economically used with burning gas to make a lime light for the illumination of stores, which can be so lit better at a cheaper rate, than with the ordinary arrangement of simple gas burners. It is, moreover, stated that a company has been established to manufacture oxygen by the above process and furnish it to consumers.

Magnesium.—From experiments made by Dr. Thomas Woods, of Parsonstown, England, it would appear that the above metal evolves in burning more heat than any other substance. As this heat is developed in a short time, and concentrated in a small mass of matter, we seem to see here a reason for that *intensity* in the light developed by this body, or the rapid rate of its vibrations, which causes it to produce a spectrum abounding in the higher blue rays, to afford a blue-white light, and to exhibit remarkable photographic energy.

The ordinary lime light, compared with other artificial sources of illumination, shows a bluish tint, and is thus often used for moonlight in theatrical effects, but, compared with magnesium, its light acquires by contrast a red tone.

This comparison was then exhibited in a striking manner, by throwing the different lights upon the screen.

The rendering gunpowder non-explosive by mixing with it some incombustible powder, thus insulating the individual grains, proposed by Mr. Gale, of Plymouth, is one of the notable and ingenious novelties of the month not to be overlooked; and lastly, we would call attention to the statement that Mr. Horzeaux has proved, in certain cases, that the coloration of iodized starch paper exposed to the air is not due to nitric acid, but must indicate the presence of ozone.

After the conclusion of the Secretary's Report, Mr. Thomas Shaw moved that the powers of the Committee on Sound Signals be extended so as to include the discussion of color signals also. This motion was carried.

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

BIBLIOGRAPHICAL NOTICES.

The Cadet Engineer; or Steam for the Student. By JOHN H. LONG, Chief Engineer, United States Navy, and R. H. BUEL, Assistant Engineer, United States Navy. Published by J. B. Lippincott & Co.

Though "the royal road to learning," that is, the way of acquiring knowledge without labor and effort, is not and never will be open to travelers, there is a great difference between the new untrodden path to knowledge, and that which has been rendered firm to the foot and clear to the eye by the tread of previous students, and freed of some obstructions by their labors. As the friends of education, we therefore hail with pleasure such publications as the foregoing, which greatly aid students in the acquisition of knowledge, by placing the facts of their subject and the reasons and connexions of these in a simple and straightforward manner before the reader.

We cannot do better than give an extract from the table of contents, to show our readers the scope and character of the present work:

"Description and statement of advantages and disadvantages of engines and boilers.

"Appendages to engines and boilers."

"The Paddle-wheel; The Screw Propeller; Combustion of Coal; Erection of Engines; Exhaustion of Steam; Cut-offs; Indicators; Valves; Scale; Condensers, &c.; Management of Engines and Boilers at Sea, &c."

In addition to the merit of "literary" clearness already mentioned, the above work is also remarkable for that care in printing and illustration which adds so much to the satisfaction experienced in reading a good book. It is printed on tinted paper, in clear, well sized type, with many illustrations, and is bound in a style which, by reason of